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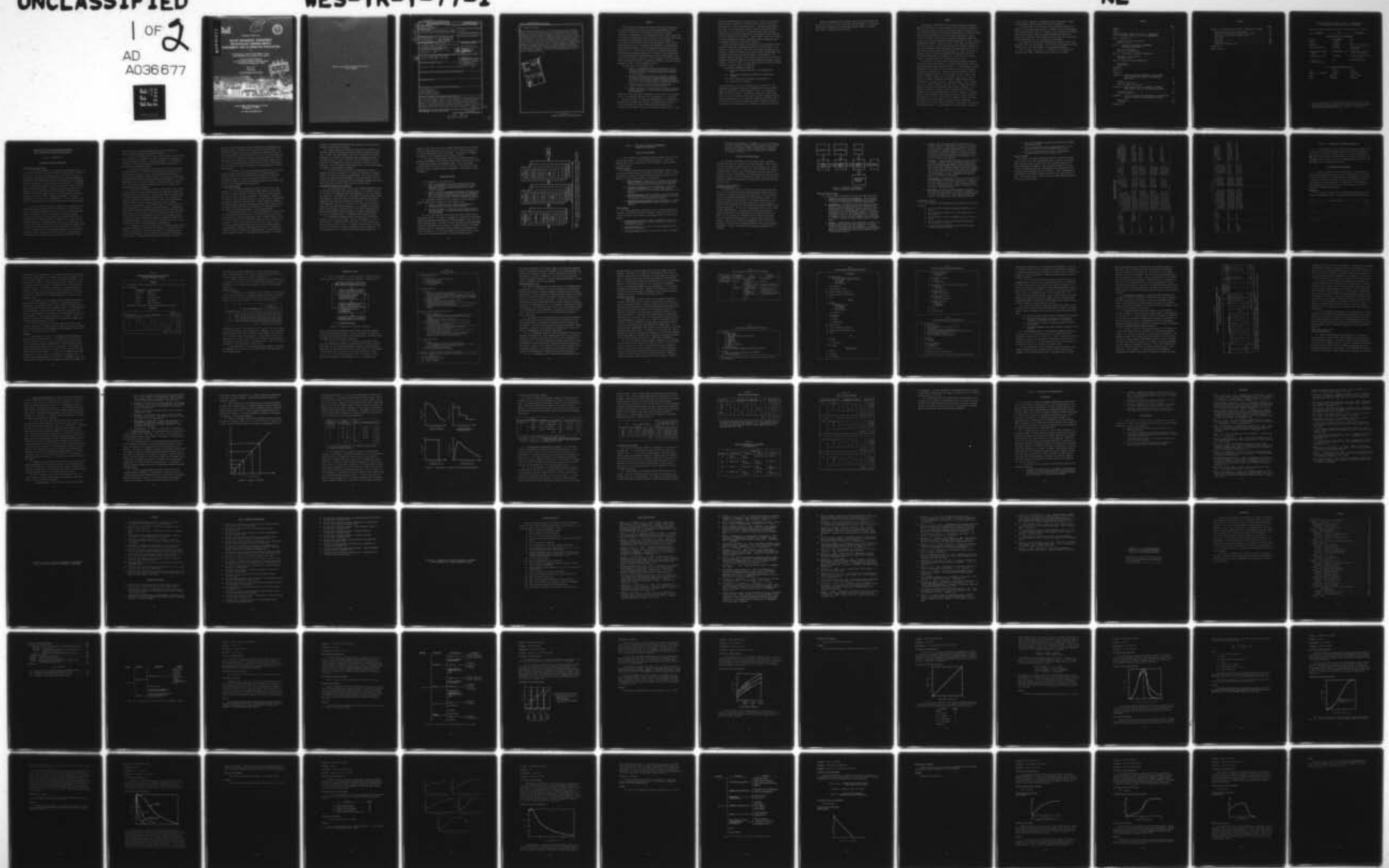

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WATER RESOURCES ASSESSMENT METHODOLOGY (WRAM)--IMPACT ASSESSMENT AND ALTERNATIVE EVALUATION

by

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The U. S. Army Corps of Engineers has been directed by various legislation, acts, and regulations to conduct systematic and comprehensive environmental planning for its activities. The thrust of this study has been to pull together the state of the art and to synthesize a water resources assessment methodology (WRAM) for impact assessment and alternative evaluation. A review of 54 impact assessment methodologies revealed that none entirely satisfied the needs or requirements for the Corps' water resources projects and programs. However,

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20. ABSTRACT (Continued)

salient features contained in several of the methodologies were considered pertinent for inclusion in WRAM. One of the features consisted of weighting impacted variables and scaling the impacts of alternatives. The resulting weighted and scaled values are multiplied to obtain final importance values. The weighted rankings technique is the basic weighting and scaling tool used in this methodology. It consists of developing relative importance coefficient values for each variable, assigning alternative choice coefficient values to each alternative in relation to its impact on each variable, and displaying the products in a final coefficient matrix. Principal components of WRAM include assembling an interdisciplinary team; selecting and measuring assessment variables; identifying, predicting, and evaluating impacts and alternatives; and documenting the analysis. Although WRAM is presented for use by the Corps in water resources management, it does have general applicability to other resource management agencies.

SUMMARY

This study was necessitated by various environmental legislation, acts, and regulations, including the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190); Executive Order 11514, "Protection and Enhancement of Environmental Quality," 1970; Section 122 of the River and Harbor and Flood Control Act of 1970 (Public Law 91-611); the Council on Environmental Quality, "Guidelines for Statements on Proposed Federal Actions Affecting the Environment," 1973; and the Water Resources Council, "Principles and Standards for Planning Water and Related Land Resources," 1973 (Principles and Standards); and the desire of the U. S. Army Corps of Engineers to conduct systematic and comprehensive environmental planning. In essence, these legislations, acts, and regulations established general but firm requirements for the Corps and other Federal agencies to conduct studies of the environmental, social, and economic effects of proposed activities at a level of detail adequate to affect the decisionmaking process.

The objectives of this study are to

a. Conduct a comprehensive review and evaluation of major impact methodologies, particularly those that have been developed for or have potential application to water resources programs.

b. Develop an assessment methodology consistent with NEPA, Principles and Standards, and Corps Engineer Regulations that can be used by Corps planners for assessing alternatives and evaluating water resources programs and projects.

c. Conduct several field tests using the methodology to determine overall utility and practicability.

d. Prepare and conduct a training course for water resources planners relative to the application and implementation of this methodology.

Objectives a and b have been accomplished and the results are presented herein. The remaining objectives will be addressed at a later date.

During this study, 54 assessment methodologies were reviewed and evaluated by a planning team composed of personnel from the Office, Chief of Engineers; the Lower Mississippi Valley Division; the Jacksonville, Sacramento, Tulsa, and Vicksburg Districts; the U. S. Army

Engineer Waterways Experiment Station; the U. S. Bureau of Reclamation; and two private consultants to determine their utility or potential applicability for water resources projects. Final screening revealed that none of the methodologies entirely satisfied the needs and/or requirements of Corps activities, although several methods contained salient features that were considered by the planning team as important for Corps assessment and evaluation. These features include the concepts of impact weighting and scaling, appropriate impact summarization and presentation techniques, and lists of variables.

Impact assessment includes consideration of the importance of each variable affected and the probable absolute or relative impacts of alternatives on each variable. Weighting involves the assignment of importance to impacted variables, and scaling includes the approaches used to address the absolute or relative impacts of alternatives. The weighted rankings technique is the procedure used in the water resources assessment methodology (WRAM) for assigning importance weights; weighted rankings, functional graphs, or linear proportioning is used for scaling, depending on available data and technology.

The essential components of WRAM are

I. Selection and Familiarization of Interdisciplinary Team

II. Selection of Assessment Variables and Environmental Inventory

III. Impact Prediction, Assessment, and Evaluation

IV. Documentation of Results

In the presentation of any such methodology, the claims of a "new" comprehensive approach should not be exaggerated nor existing limitations for application be underestimated. Many of the components of WRAM have been used before. In addition, limitations in the present state of the art of variable measurement and impact assessment and prediction preclude the level of objective, analytical evaluation that is often desired. However, the dynamic character of WRAM will allow incorporation of new information and technology as they become available.

Specific recommendations for related research activities identified by, but not a part of, this study include the development of (a) function graphs and (b) techniques for predicting probable changes in variables as a result of implementing alternatives.

PREFACE

This research, Evaluation of Environmental Assessment Techniques, Work Unit CWIS 31443, was conducted under the Civil Works Environmental Impact Research Program. This interim report presents conclusions based on review and evaluation of major impact methodologies, particularly those that have been developed for or have potential application for water resources programs, and develops an assessment methodology (WRAM) that can be used to assess impacts and evaluate alternatives for water resources programs and projects. Additional goals of this study, not addressed in this report, will be to (a) develop a statistical analysis component to test for significant differences between and among alternatives (FY 77); (b) conduct a rigorous field testing program (FY 77-78); (c) develop a computer program to assist with mathematical computations (FY 78); (d) continue interagency coordination (FY 77-78); and (e) develop and conduct a training program for potential users (FY 78-79).

The portion of the study reported herein was conducted during the period June 1975-December 1976 by an interdisciplinary study team from the Environmental Effects Laboratory (EEL), U. S. Army Engineer Waterways Experiment Station (WES), and two consultants, with overall guidance provided by a planning team. The study team was composed of and the report prepared by Messrs. R. Charles Solomon, Billy K. Colbert, and William J. Hansen, and Ms. Sue E. Richardson, EEL; and Drs. Larry W. Canter, University of Oklahoma, and Evan C. Vlachos, Colorado State University. The planning team was composed of Messrs. Jack R. Bernard and Fred J. Kindel, Sacramento District; John B. Bushman and Richard L. Makinen, Office, Chief of Engineers (OCE); James R. Chambers, H. Tom Holland, and Norwin E. Johnson, Lower Mississippi Valley Division; Rudolph A. Nyc, Jacksonville District; Ernest E. Parks, Jr., Vicksburg District; James Randolph, Tulsa District; George H. Wallen, Bureau of Reclamation; Drs. Rex L. Eley, Walter B. Gallaher, Luther F. Holloway, and Conrad J. Kirby, EEL; Messrs. Solomon, Colbert, and Hansen; Ms. Richardson; and Drs. Canter and Vlachos. Additionally, the study was coordinated with the U. S. Environmental Protection Agency, Department of the Interior, Department of Housing and Urban Development, Council on Environmental Quality, and National Science Foundation.

The constructive criticisms and helpful comments prepared by the members of the planning team and Drs. Al Schaffer, Sociology Department, Texas A&M University; Patricia K. Guseman, Texas Transportation Institute, Texas A&M; and Fred W. Grupp, Sociology Department, University of Connecticut; and Messrs. Glenn Loomis and Gerry Lowry, Soil Conservation Service, Washington, D. C., are gratefully acknowledged.

This study was performed under the general direction of Drs. John Harrison, Chief, EEL, and Conrad J. Kirby, Chief, Environmental Resources Division, EEL. Mr. John Bushman, OCE, was technical monitor.

COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Directors of WES during the study. Technical Director was Mr. F. R. Brown.

CONTENTS

CONTENTS

CONVERSION FACTORS, METRIC (SI) TO U. S. CUSTOMARY AND U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

Units of measurement used in this report can be converted as follows:

Multiply	By	To Obtain
	Metric (SI) to U. S. Customary	
microns	0.003280839	feet
metres	3.280839	feet
kilometres	0.6213711	miles (U. S. statute)
square kilometres	0.3861021	square miles (U. S. statute)
micrograms per cubic metre	$0.000133526 \times 10^{-6}$	ounces (mass) per gallon (U. S. liquid)
milligrams per litre	0.0000083	pounds (mass) per gallon (U. S. liquid)
Kelvins or Celsius degrees	9/5	Fahrenheit degrees*
	U. S. Customary to Metric (SI)	
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
acres	4046.856	square metres
tons	907.1847	kilograms

* To obtain Fahrenheit (F) temperature readings from Celsius (C) readings, use the following formula: $F = 9/5(C) + 32$. To obtain Fahrenheit readings from Kelvins (K), use: $F = 9/5(K - 273.15) + 32$.

WATER RESOURCES ASSESSMENT METHODOLOGY (WRAM)-- IMPACT ASSESSMENT AND ALTERNATIVE EVALUATION

PART I: INTRODUCTION

Background for Impact Assessment

Legislation and regulations

1. Prior to the enactment of the National Environmental Policy Act (NEPA) of 1969 (Public Law (PL) 91-190), projects under the direction of the U. S. Army Corps of Engineers, the U. S. Forest Service, and several other Federal agencies were controlled by internal regulations and/or policy requirements that resulted in an impact survey, assessment document, base survey, or similar review for each project. The purpose of such reviews was to delineate changes in land use, resource development, or resource management. Generally, the resulting report was not provided to other Federal agencies or the public for formal review. However, with increased public interest in the environment and resource protection in the late 1960's, Congress passed NEPA. The primary importance of this act was the establishment of a broad national policy directing Federal agencies to maintain and preserve environmental quality.

2. The most significant feature of NEPA is the requirement for an environmental impact statement (Section 102(2)(c)). This section requires all Federal agencies and officials to (a) direct their policies, plans, and programs to protect and enhance environmental quality; (b) view their actions in a manner that will encourage productive and enjoyable harmony between man and his environment; (c) promote efforts that will minimize or eliminate adverse effects to the environment and stimulate the health and well-being of man; (d) promote the understanding of ecological systems and natural resources important to the Nation; (e) use a systematic and interdisciplinary approach that integrates the ecological, social, cultural, and economic factors in planning and decisionmaking; (f) study, develop, and describe alternative actions

that will avoid or minimize adverse impacts; and (g) evaluate the short- and long-term impacts of proposed actions.

3. NEPA also established the Council on Environmental Quality (CEQ), one of the functions of which is to issue guidelines for preparing environmental impact statements. All Federal agencies, in consultation with CEQ, are required to develop their own internal instructions or regulations for implementing NEPA.

4. Subsequent legislation in Section 122 of the River and Harbor and Flood Control Act of 1970 (PL 91-611) directed the Corps to promulgate guidelines designed to ensure that possible adverse economic, social, and environmental effects related to flood control, navigation, and associated plans were considered during plan formulation. An effects assessment report, required in response to this legislation, parallels and is concurrent with plan formulation and is used as input to the environmental impact statement.

5. After the effective date of NEPA (1 January 1970), the Corps of Engineers along with other Federal agencies was required to prepare environmental impact statements on a backlog of projects in various stages of planning, design, construction, and operation. The compilation of required information in sufficient detail to affect the decisionmaking process, however, requires qualified personnel, time, and money. Initially, the personnel, time, and funds required to process this backlog of projects were not available to Federal agencies. Consequently, environmental impact statements prepared by most Federal agencies during 1970 and 1971, in the absence of specific guidance by Congress or CEQ, were very brief; did not adequately describe the environmental impacts of proposed projects, especially secondary and cumulative impacts; did not adequately address a wide spectrum of alternatives and their various impacts; and did not actively seek public participation.

6. Subsequent to NEPA and Section 122 of PL 91-611, a broad and comprehensive regulation, "Principles and Standards for Planning Water and Related Land Resources," hereafter referred to as Principles and Standards, was developed by the Water Resources Council (Water Resources Council 1973). Principles and Standards was developed to promote the

quality of life by reflecting society's preferences for enhancing both national economic development and the quality of the environment. The "Principles" provide a broad policy framework for planning activities, and the "Standards" provide operational criteria for achieving uniformity and consistency in comparing, measuring, and judging beneficial and adverse effects of alternatives. Principles and Standards applies specifically to all Corps Civil Works projects and to all other Federal agency projects related to planning, developing, and managing water or related land resources.

7. In response to the planning requirements developed by the Water Resources Council, the Corps has developed the Engineer Regulation (ER) 1105-2-200 series to establish internal guidance for conducting feasibility studies for water and related land resources, and the ER 1105-2-421 series to clarify environmental quality factors that should be taken into consideration during planning.

Need for methodologies

8. Water resources programs and projects, like all Civil Works projects, are very broad and frequently highly complex from the standpoint of the diverse biological, chemical, physical, social, cultural, and economic factors that may be affected. Consequently, evaluation of the effects of water resources projects on the environment is complicated and should be approached systematically. These complexities mandate a flexible assessment approach or methodology rather than a rigidly structured system that would inhibit the application of knowledge and the exercising of professional judgment by Corps field personnel.

9. One important purpose of an impact methodology is to ensure that all assessment variables that need to be considered (as determined by the planning team, internal regulations, State or Federal laws, or concerned citizens groups) are included in impact analysis, assessment, and evaluation. Ideally, a methodology should provide a means of identifying data needs and determining priorities for allocating resources. An environmental assessment method should also provide a framework for evaluating alternative plans on a comparable basis. Finally, methodologies should be useful in evaluating the effectiveness of mitigation

measures, in considering trade-offs among alternative actions, and in formulating additional alternatives.

10. Federal agencies, universities, and private consultants have developed numerous environmental impact assessment methodologies since 1970. Despite these developments, there are no universally acceptable techniques or procedures for conducting impact assessments because of the high diversity of types of projects, the particularities of each situation, and changing sociocultural conditions. However, there are features of various assessment methodologies that, if used, would enhance the conduct of environmental assessment.

11. The Water Resources Council has recognized the need for planning tools and for research to increase the efficiency of planning efforts. According to Principles and Standards, "The Council will encourage and support needed improvements in the application of the conceptual and theoretical planning and decisionmaking framework upon which these Principles are based" (Water Resources Council 1973).

Environmental assessment in planning

12. The overall objective of the Corps' planning framework, based on the legal requirements discussed previously, is to develop plans for the conservation, development, and wise management of water and related land resources. Information must be obtained, often from detailed field reconnaissance, before decisions can be made concerning wise resource management under existing and projected conditions. If the Corps is to be responsive not only to the letter but to the intent of current legislative and administrative mandates, it is paramount that environmental studies become an integral part of the Corps' planning process and that environmental impact assessments be prepared simultaneously with and in comparable detail to engineering and economic studies.

13. The general planning process as outlined in ER 1105-2-200 consists of three planning stages: Stage 1, development of a plan of study; Stage 2, intermediate plans; and Stage 3, detailed plans; and four functional planning tasks: (a) problem identification, (b) formulation of alternatives, (c) impact assessment, and (d) evaluation. The four planning tasks are undertaken during each stage; however, the

emphasis on the task varies (e.g., problem identification is of greatest concern in developing the plan of study, but is of lesser importance in developing intermediate and detailed plans). Environmental assessment and evaluation are predominant tasks in Stages 2 and 3.

14. The three planning stages provide for an orderly analysis in which the development of increasingly detailed data and alternative plans is accomplished during each subsequent stage. In the final stage, precisely defined concepts of resource management that have been developed into specific detailed plans are presented. This process is shown in Figure 1.

Purpose and Scope

15. The purposes of this study are to

a. Conduct a comprehensive review and evaluation of major impact methodologies, particularly those that have been developed for or have potential application for water resources programs.

b. Develop a flexible assessment methodology, consistent with NEPA, Principles and Standards, and Corps ER's (Appendix A), that can be used by Corps planners for assessing alternatives and evaluating water resources programs and projects.

16. Additional objectives of this research, to be developed in future studies but not addressed in this report, are to

a. Conduct several field tests using the methodology to determine overall utility and practicability.

b. Prepare and conduct a training course for water resources planners relative to the application and implementation of this methodology.

17. Due to the nature of the problem, the scope of this study is necessarily general. The report is designed as a guideline for assessing impacts and evaluating alternatives in planning tasks (c) and (d) of the three planning stages. The water resources assessment methodology (WRAM) provides a framework that will permit a systematic approach to planning consistent with the requirements of the Principles and Standards and Corps' regulations. It has been developed on the premise that it will be used at the operational level for Corps Civil Works projects.

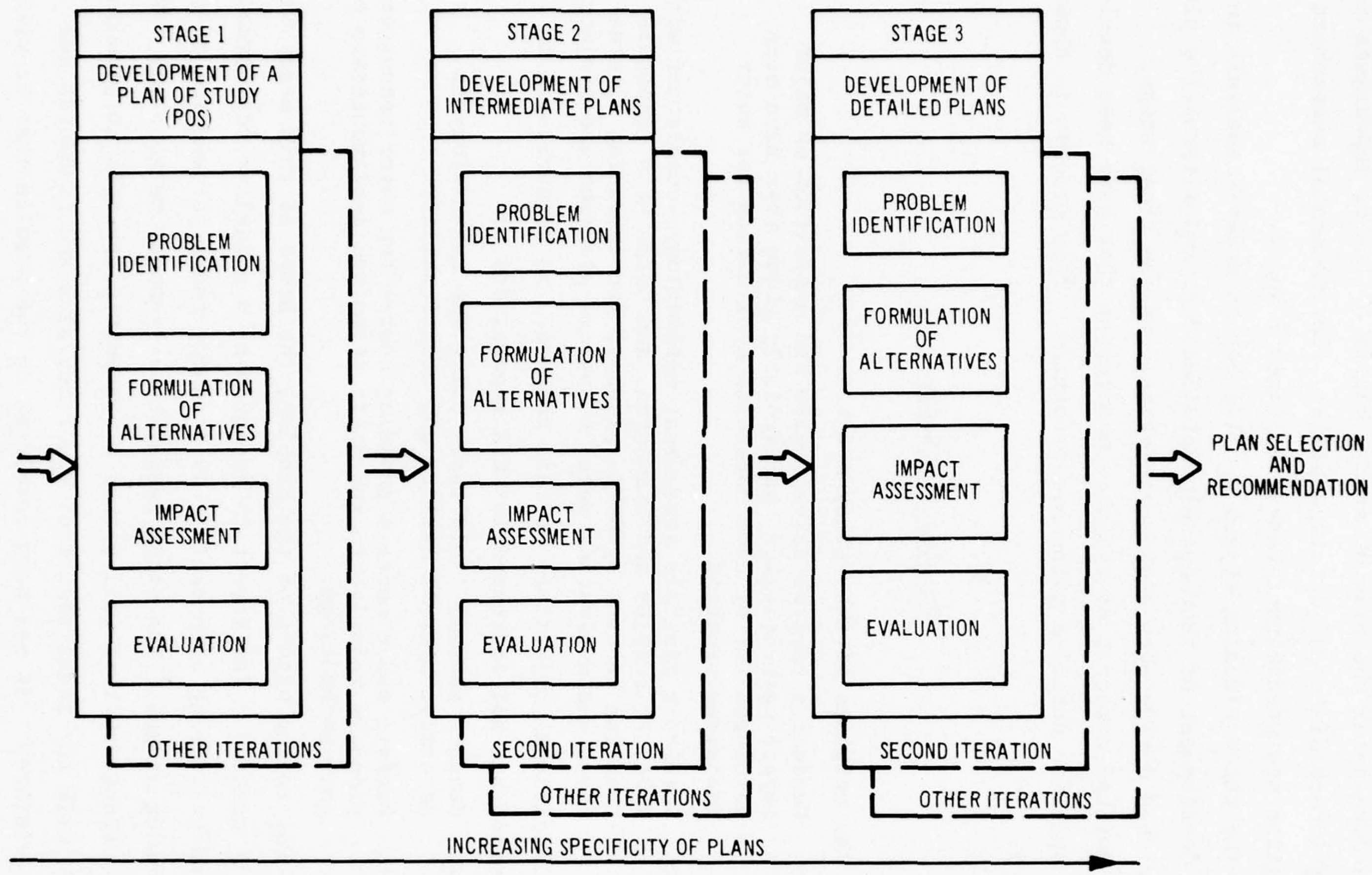

Figure 1. General relationship of plan development stages and functional planning tasks.
Note: The varying size of blocks representing each planning task suggests the relative importance of planning tasks during Stages 1-3 (from ER 1105-2-200)

PART II: EVALUATION OF EXISTING ENVIRONMENTAL ASSESSMENT METHODOLOGIES

Types of Methodologies

18. Most methods of environmental impact assessment can be divided into two major groups: checklist methods and matrices. Remaining methodologies can be categorized as ad hoc procedures, overlay methods, or network methods.

Checklist methods

19. Checklist methods list variables and potential impacts typically associated with particular categories of projects. Users of checklists select variables from a master list and evaluate impacts that are expected to result from a variety of alternatives.

- a. Simple checklists include a list of variables and potential impacts; however, no guidelines are provided on how these variables and impacts are to be measured or interpreted.
- b. Descriptive checklists are more informative in that they include an identification of variables and potential impacts and provide guidelines on how these items are to be measured.
- c. Scaling checklists, which are similar to descriptive checklists, provide additional techniques necessary to determine the absolute or relative measures of impacts.
- d. Weighting-scaling checklists provide techniques for scaling impacts and assigning relative importance weights to each variable.

Matrix methods

20. Matrix approaches incorporate a list of project activities in addition to a checklist of potential impacts. These two lists are related in a matrix that identifies relationships between activities and impacts.

- a. A simple matrix approach to impact assessment is based on a two-dimensional checklist of project activities and potential environmental impacts.
- b. The scaling matrix can be used to indicate magnitude and importance of each impact.
- c. The stepped matrix approach can be used to indicate secondary

and interrelated impacts. For example, if it can be shown that a project action will impact a specific variable, that variable can then be analyzed to document the influence of projected changes of the variable on other variables being considered. This concept provides a method for identifying cross-impacts and interactive effects.

Evaluation of Methodologies

21. Many basic frameworks for environmental impact assessment methodologies have been developed since the enactment of NEPA; however, most were developed to address specific project problems (e.g., Walton and Lewis 1971 and Arthur D. Little, Inc., 1971 addressed the impacts of transportation). Many of these methodologies have been categorized according to various characteristics and evaluated against certain reviewer-specified criteria. The most comprehensive reviews are those conducted by Drobney and Smith 1973, Warner and Preston 1974, Jain and Urban 1975, and Canter 1977.

Selecting a water resources planning methodology

22. During this study, an intensive literature review was made by the U. S. Army Engineer Waterways Experiment Station (WES) study team to identify existing methodologies and determine if any could directly serve as an assessment methodology for water resources projects. Initially, two general characteristics, (a) previous application to water resources projects and (b) potential application to water resources projects, were established for evaluating 54 environmental impact methodologies (Appendix B). A total of 21 methodologies met one or the other of these characteristics. Secondly, 19 desirable characteristics (listed in Appendix B) were developed for intermediate screening, by which 8 of the remaining 21 methodologies were identified as having sufficient desirable characteristics to warrant further evaluation. Finally, seven criteria (listed in paragraph 23) were used for final screening. These seven are considered essential for a Corps assessment methodology. Figure 2 illustrates the screening procedure that was followed.

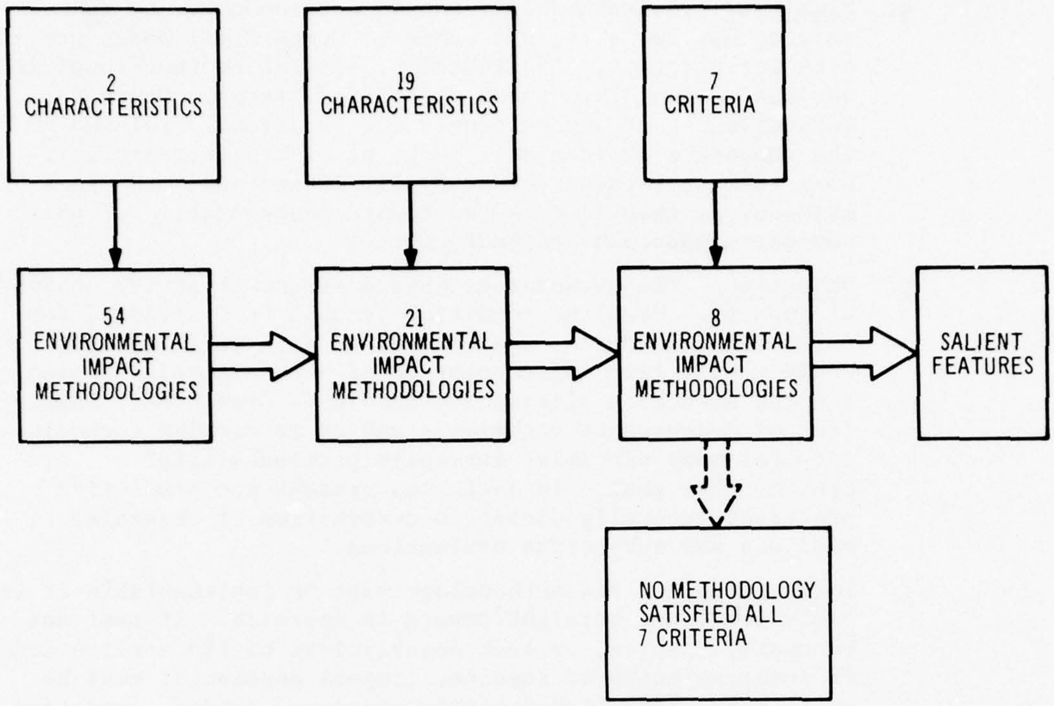

Figure 2. Screening of environmental impact assessment methodologies

<u>Final screening criteria</u>

23. The seven final screening criteria are described as follows:

- a. <u>Responsive to Principles and Standards.</u> The methodology should be responsive to the planning concepts and system of accounts as delineated in Principles and Standards.
- b. <u>Comprehensive.</u> The methodology should address the various impacts of water resources projects and programs on the physical-chemical, biological, cultural, and socioeconomic environments. The methodology should encompass all potential beneficial and detrimental impacts. It should also highlight key issues or allow special emphasis on factors of national, state, or local importance (e.g., threatened or endangered species, historic landmarks, and archaeological sites) or factors of intense public concern or controversy.
- c. <u>Dynamic.</u> The methodology should be dynamic in terms of the variables considered and the technology used for impact identification, prediction, and assessment. It should be capable of including additional variables and incorporating additional measurement and predictive techniques as technology becomes available.

d. Flexible. The methodology should be responsive to the varying nature, size, and scope of Corps Civil Works projects and programs. Additionally, it must be functional in various regions throughout the United States. Since the effectiveness of impact assessment is directly related to the composite professional judgment of the interdisciplinary team performing the study, it is necessary to use a methodology that is directed toward incorporation of this composite approach and judgment.

e. Objective. The methodology should stress objective analyses of impacts. Baseline conditions should be quantified for variables considered, and changes in each variable that would result from implementation of each alternative plan and the no-action alternative should be predicted. However, lack of measurement techniques and/or predictive technologies for many variables currently precludes total achievement of this goal. In fact, measurement and prediction practices generally dictate a combination of objective analyses and subjective evaluations.

f. Implementable. The methodology must be implementable at the field level and straightforward in approach. It must not be overly complex, or lack descriptions of its application or interpretation of results. Impact assessment must be able to be accomplished within manpower, funding, and time constraints of Corps Districts.

g. Replicable. The results achieved should be replicable. The methodology must provide a sufficient framework so that different interdisciplinary teams using the methodology for the same study will arrive at the same conclusions with regard to the evaluation of the alternatives examined.

Methodologies selected

24. The following eight methodologies were subjected to the final screening:

a. The Battelle Environmental Evaluation System (Dee et al. 1972).

b. The Tulsa District method (U. S. Army Engineer District, Tulsa, 1972).

c. The Multiagency Task Force method (Bureau of Reclamation 1972).

d. The Environmental Impact Center method (Environmental Impact Center, Inc., 1973).

e. The Battelle Water Resources Project method (Battelle-Columbus Laboratories 1974a).

f. The Battelle Dredging Assessment method (Battelle-Columbus Laboratories 1974b).

g. The Lower Mississippi Valley Division method (U. S. Army Engineer Division, Lower Mississippi Valley, 1976).

h. The Soil Conservation Service Guide to Environmental Assessment (Soil Conservation Service 1974).

Salient features

25. None of the eight methodologies entirely satisfied all seven criteria used in the final screening procedure. However, each methodology contained salient features that were considered important for Corps environmental assessment. These features included the concepts of impact weighting and scaling, appropriate impact summarization and presentation, and extensive lists of variables. Table 1 summarizes the characteristics and salient features of each of these eight methodologies. The concepts basic to these features are developed and described in Part III of this report.

Table 1

Summary of Salient Features of Eight Water Resources Impact Methodologies

Methodology	Type of Methodology	Variables Considered	Weighting Approach	Scaling Approach	Impact Summarization and Presentation
Battelle Environmental Evaluation System	Weighting-scaling checklist	Good listing of biological, physical-chemical, esthetic, and cultural variables. Less emphasis on many factors associated with SWB and RD accounts. The variables listed are well described in terms of measurement units and evaluation. No information is provided on technical aspects of impact prediction.	Use of ranked pairwise comparison technique for allocation of importance weights to system variables.	Use of function graphs with scale of 0 (bad) to 1 (good).	Products of importance weights times scale values are tabulated and presented by major environmental categories as well as the totals for all categories.
Tulsa District	Weighting-scaling checklist; also called matrix by preparers	Has good list of variables for EQ, SWB, and RD accounts. Minimal information is provided on definition, measurement, and evaluation of variable. No information is provided on technical aspects of impact prediction.	Assignment of importance weights to variables by collective professional judgment of interdisciplinary team.	Use of relative scale of +5 (most beneficial plan) to 0 (no-action alternative) to -5 (most detrimental plan).	Products of importance weights times relative impact values are presented by major environmental categories as well as the totals for all categories.
Multiagency Task Force	Scaling checklist	Good listing of variables for biological, physical-chemical, esthetic, and cultural environments. Minimal emphasis to a number factor in current SWB and RD accounts. The variables listed are well described in terms of measurement units and human influence. No information is provided on technical aspects of impact prediction.	No numerical system used. Importance weighting based on collective professional judgment of interdisciplinary team.	Use of quantitative data plus quality scale of 10 (good) to 0 (bad), and human influence scale of 10 (good) to 0 (bad).	Quantitative data are presented for each variable along with quality scale values and human influence scale values.
Environmental Impact Center	Descriptive checklist	Has good list of variables for biological and physical-chemical environment. Emphasis is also given to many factors in the SWB and RD accounts and their interrelationships with both the natural systems and the human system. For certain biological and physical-chemical variables, information is provided on impact prediction.	No numerical system used. Importance weighting based on collective professional judgment of interdisciplinary team.	Quantitative impact predictions used. No special scaling system involved. Collective professional judgment of interdisciplinary team used.	Quantitative impact predictions are presented. No numerical weighting or scaling methods are used.
Battelle Water Resources Projects	Descriptive checklist	Primary orientation is to reservoir projects. Good listing of variables for EQ, SWB, and RD accounts. The variables listed are well described in terms of measurement units and evaluations. Information is provided on the technical aspects of impact prediction for water quality and ecological impacts.	No numerical system used. Importance weighting based on collective professional judgment of interdisciplinary team.	Quantitative impact predictions used. No special scaling systems involved. Collective professional judgment of interdisciplinary team used.	Quantitative impact predictions are presented. No numerical weighting or scaling methods are used.

(Continued)

Note: SWB = *Social Well-Being*
RD = Regional Development
EQ = Environmental Quality

Table 1 (Concluded)

Methodology	Type of Methodology	Variables Considered	Weighting Approach	Scaling Approach	Impact Summarization and Presentation
Battelle Dredging Assessment	Descriptive checklist	Primary orientation is to dredging projects. Good listing of variables for EQ, SWB, and RD accounts. The variables are well described in terms of measurement units and evaluation. Information is provided on the technical aspects of impact prediction for many variables.	No numerical system used. Importance weighting based on collective professional judgment of interdisciplinary team.	Quantitative impact predictions used. No special scaling systems involved. Collective professional judgment of interdisciplinary team used.	Quantitative impact predictions are presented. No numerical weighting or scaling methods are used.
Lower Mississippi Valley Division	Weighting-scaling checklist	Good listing of natural environment variables for EQ account. No emphasis given to SWB and RD accounts. Information is provided on the measurement units and evaluation of variables. No information is provided on the technical aspects of impact prediction.	Assignment of importance weights to system variables by collective professional judgment of interdisciplinary team.	Use of quantitative data plus function graphs with scale 1' (good) to 0 (bad).	Products of acres of habitat types times scale values times important weights are presented by habitat type. Totals for all habitats in an area can be evaluated.
Soil Conservation Service Guide to Environmental Assessment	Scaling checklist	Good listing of variables for EQ account. Minimal emphasis on variables for SWB and RD accounts. The variables listed are well described in terms of measurement units. No information is provided on technical aspects of impact prediction.	No numerical system used. Importance weighting based on collective professional judgment of interdisciplinary team.	Use of quantitative data plus quality scale of 5 (excellent) to 1 (unsuited) for various resource uses.	Quantitative data are presented for each variable along with resource use scale values.

26. In the immediate future, field testing and review comments will be used to revise the present WRAM framework for potential implementation as part of the Corps' planning process. Even with implementation, WRAM will be evolutionary as field applications, additional reviews, and improvements in the state of the art of impact modeling, prediction, and assessment result in appropriate revisions.

Weighting-Scaling Technique

27. Impact assessment includes consideration of the importance of each impacted variable and the absolute or relative impacts of alternatives on each variable. Weighting involves the assignment of importance to impacted variables, and scaling includes the approaches used to reflect absolute or relative impacts of alternatives. The principles of the weighting-scaling technique used in this methodology have been described by Dean and Nishry (1965).

Weighting

28. An example is presented in the following tabulation to illustrate the weighting procedure. Six hypothetical impacted variables are

Variable	Assignment of Importance Values																					Sum	RIC
V1	0	1	1	0	0	1																3.0	0.14
V2	1						1	0.5	0.5	1	1											5.0	0.24
V3		0					0					0.5	0	0.5	1							2.0	0.09
V4			0					0.5				0.5				0.5	0	1				2.5	0.12
V5				1					0.5				1			0.5			1	1		5.0	0.24
V6					1					0				0.5			1		0		1	3.5	0.17
V7 (Dummy)						0					0				0			0		0	0	0.0	0
																				Total		21.0*	1.00**

*Check: $\frac{N(N-1)}{2} = \frac{7(7-1)}{2} = \frac{42}{2} = 21$

**Must sum to unity

shown along with a dummy variable. The dummy variable, which by definition has no relative impact, is included to preclude any impacted variable from being assigned a value of zero (no relative importance). Each variable in the example is compared with every other variable in order to determine which of each pair is considered to be the most important for the study area. The variable considered to be more important is assigned a value of one, and a value of zero is assigned to the other. If a decision cannot be made regarding relative importance, or if both variables are considered to be of equal importance, a value of 0.5 is assigned to each.

29. The columns in the tabulation under the heading "Assignment of Importance Values" represent the results of the variable-by-variable comparisons. The assigned values for each variable are summed, and each sum is divided by the total of all assigned values, 21, to determine the relative importance coefficient (RIC). Two checks concerning the accuracy of the mathematical calculations can be made using the totals in the tabulation: the sum column should total to $N(N-1)/2$, where N is equal to the number of variables considered (including the dummy); and the RIC column should total to unity.

30. The RIC column in the tabulation shows the ranking of each variable considered. The dummy variable is zero (no priority) by definition, and the ordering of the remaining six, from highest to lowest priority, is V2 and V5, V6, V1, V4, and V3.

Scaling

31. An example of the use of the weighted rankings technique for impact scaling is shown in Table 2. The impacts of four alternative plans on Variable X are to be scaled. The predicted impacts as shown can be described in absolute (quantitative) or relative (qualitative) terms, with relative values shown for illustration. The procedure involves simply deciding which of two plans at a time would have the most beneficial impact on Variable X. A value of 1 is assigned to the more desirable of the pair, and the less desirable is assigned a zero. If two plans have similar impacts, a value of 0.5 is assigned to each. The columns under the heading "Choice Assignment" represent the results of

Table 2

Scaling of Impacts on Variable X Using Weighted Rankings Technique

Problem

The impacts of five alternatives on Variable X have been predicted to be as follows:

Alternative	Predicted Impact
No Action	Beneficial
Plan A	Beneficial
Plan B	Most beneficial
Plan C	Detrimental
Plan D	Most detrimental

Determine scaled values using weighted rankings technique.

Solution

Alternative	Choice Assignment										Choice Total	ACC
No Action	0.5	0	1	1							2.5	0.25
A	0.5				0	1	1				2.5	0.25
B		1			1			1	1		4	0.40
C			0			0		0		1	1	0.10
D				0			0		0	0	0	0.00
										Total	10	1.00

the step-by-step pairwise comparisons. Plan B, with an alternative choice coefficient (ACC) of 0.4, would be the most beneficial alternative considering the potential impacts on Variable X.

32. Impact scaling can also be accomplished either through the use of functional curves or the use of a linear scaling technique. These two techniques will be subsequently discussed as a part of the assessment methodology.

Display of results

33. The results of the weighting-scaling technique are displayed in a final coefficient matrix. An example of the final coefficient matrix listing the RIC's for five variables and ACC's for four alternatives is shown in the following tabulation. The final coefficient matrix

		ACC of Alternative				Final Coefficient Matrix RIC × ACC			
Variable	RIC	A	B	C	D	A	B	C	D
V1	0.20	0.25	0.25	0.40	0.10	0.05	0.05	0.08	0.02
V2	0.40	0.33	0.00	0.17	0.50	0.13	0.00	0.07	0.20
V3	0.10	0.30	0.30	0.20	0.20	0.03	0.03	0.02	0.02
V4	0.20	0.30	0.30	0.30	0.10	0.06	0.06	0.06	0.02
V5	0.10	0.50	0.17	0.33	0.00	0.05	0.02	0.03	0.00
					Total	0.32	0.16	0.26	0.26

represents a display of the products of RIC's and ACC's of each alternative for each variable under consideration. Summation of the individual values as shown in the final coefficient matrix leads to the identification of the most beneficial alternative. In the example shown in the tabulation, Alternative A would be the most desirable, and Alternative C or D would be the second choice. Alternative A has a value of 0.32, and Alternatives C and D each have a value of 0.26.

34. The principles of the weighting-scaling technique as described in paragraphs 28-33 are used in the various steps of WRAM described in the following section.

Components of WRAM

35. Figure 3 illustrates the basic components of WRAM, and Table 3 lists specific steps associated with each component. WRAM should be

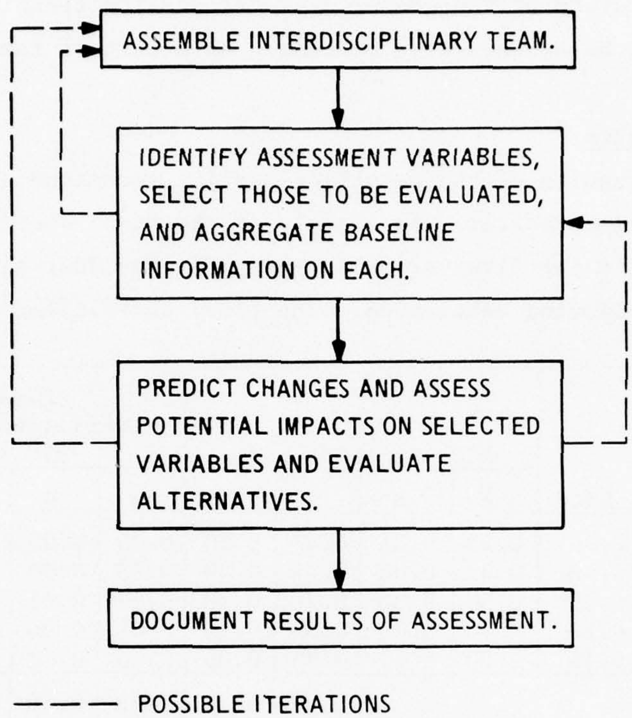

Figure 3. Components of assessment methodology

used by following the individual steps associated with each component in the order presented in Table 3. Several iterations of these steps will generally be required during each planning stage. The dashed lines in Figure 3 illustrate possible iterations.

36. WRAM is not a panacea for identifying, predicting, assessing, and evaluating the impacts of alternative water resources development plans. It is currently impossible to develop a detailed methodology that will meet the unique needs for every study in every geographic location within the jurisdiction of the Corps of Engineers. WRAM, as is true for all other methodologies, is not a substitute for the professional judgment of decisionmakers, nor is it intended to be

Table 3

Components of WRAM

I. Interdisciplinary Team

- A. Selection
  1. Select members of interdisciplinary team.
  2. Designate team leader.
- B. Review and Familiarization
  1. Review study area history.
  2. Visit study area.

II. Assessment Variables

- A. Selection
  1. Assemble list of mandatory* or critical** variables for each of the four national accounts (EQ, NED, SWB, and RD).†
  2. Use criteria questions or weighting portion of weighted rankings technique, along with professional judgment, to select additional relevant variables.
  3. Identify any resulting interactive or cross-impact variables or categories.
- B. Environmental Inventory
  1. Assemble extant baseline data for selected variables.
  2. Identify variables with data deficiencies.
  3. Use weighted rankings technique and other criteria to allocate manpower and funding resources to data collection effort.
  4. Conduct field studies or assemble information on data-deficient input variables.

III. Impact Prediction, Assessment, and Evaluation

- A. Prediction and Delineation
  1. Predict changes in each variable for each alternative plan and the no-action alternative using available techniques and/or professional judgment.
  2. Delineate potential impacts of alternatives.
  3. Highlight significant impacts and "red flag" any critical issues.
- B. Weighting and Scaling
  1. Use weighted rankings technique to determine relative importance coefficients (RIC) for each variable.
  2. Scale predicted impacts through development of alternative choice coefficients (ACC) or use of function graphs or linear scaling.
- C. Evaluation and Interpretation of Results
  1. Multiply RIC's by ACC's to obtain final coefficient matrix. Sum coefficient values for each alternative.
  2. Use values in final coefficient matrix as basis for description of impacts of alternatives and trade-offs between alternatives.
  3. Discuss any critical issues and predicted impacts.

IV. Documentation of Results

- A. Rationale
  1. Describe rationale for selection of decision variables.
  2. Describe procedure for impact identification and prediction, and rationale for weighting, scaling, and interpreting results.
- B. Referencing of Sources of Information
- C. Decision on Environmental Impact Statement

* Mandatory = variables required by legislation or regulations.

** Critical = variables that are not mandatory but usually impacted by water resources projects.

† EQ = Environmental Quality
NED = National Economic Development
SWB = Social Well-Being
RD = Regional Development

the only decisionmaking tool; however, WRAM can aid the decisionmaking process by providing a systematic framework for an interdisciplinary assessment of the impacts of water resources management alternatives. Although WRAM is presented primarily for use by the Corps in its water resources management program, it does have general applicability to other resource management agencies and programs.

Interdisciplinary team

37. Effective implementation of WRAM requires an interdisciplinary team approach. As a minimum, the team should include representatives from the disciplines of ecology, economics, engineering, and sociology/anthropology. District specialists representing the required disciplines include environmental planners, biologists, economists, engineers, sociologists, and outdoor recreation planners. If specialists from each discipline are not available from District staffs, qualified representatives from coordinating agencies, local colleges or universities, private consultants, or the interested public could be used as team participants. It is advisable that each team member be sensitive to the other disciplines involved and supportive of the interdisciplinary approach to impact assessment.

38. One member of the interdisciplinary team should be designated as team leader with the overall responsibility for planning and coordinating the specific environmental assessment study and documenting the findings. The team leader should have practical knowledge of impact assessment, sensitivity to the questions and approaches of other disciplines, and management and leadership capabilities.

39. All team members should be familiar with WRAM, Principles and Standards, CEQ guidelines, Corps planning regulations, and a variety of legislative and agency guidelines that establish the requirements for planning efforts. Effective planning also requires familiarity with the environmental conditions and public preferences within the study area. Accordingly, periodic trips by members of the interdisciplinary team to establish sensitivity to the study area are required to develop and maintain an understanding of changing conditions and preferences.

40. It is recognized that the composition and leadership of the

interdisciplinary team may change over the multiple stages in project planning. Additions to or changes in team membership should be considered as more detailed investigations and plans result in identification of critical problem areas outside the expertise of existing team members. Although participation by personnel from all of the disciplines involved in the planning effort will be included in the assessment process, continuous participation of all team members is not required throughout each planning stage. Therefore, the dynamic nature of the team and the work efforts make it imperative that detailed records and documentation be kept throughout the planning effort.

Assessment variables

41. Selection. No single "best" list of important assessment variables can be developed that would be applicable to all water resources development studies. A general categorization that can provide direction to the planning effort in identifying and describing environmental characteristics and conditions is presented in this section. Additional discussion on the selection of assessment variables is presented in Appendix C. Principles and Standards requires that significant impacts of a proposed action on the environment be measured and the results displayed, or accounted for, in terms of contributions to four accounts: National Economic Development (NED), Environmental Quality (EQ), Social Well-Being (SWB), and Regional Development (RD). In response to these requirements, WRAM provides for the grouping of variables associated with each account. The impacts on each account are then independently predicted, assessed, and evaluated. This procedure enables the relative impacts of alternatives on individual accounts and significant trade-offs between accounts to be identified and displayed.

42. The four accounts and their major categories to be considered for all water resources projects are shown in Table 4. Critical variables for Corps water resources planning applications are presented for each of the four accounts in Tables 5-8. Critical variables are those (a) specifically identified for coverage by Corps regulations and/or (b) always impacted by water resources projects. Appendix C presents pertinent information on some critical variables, including

Table 4

Four Accounts for Water Resources Project Planning

National Economic Development	Environmental Quality	Social Well-Being	Regional Development
Project Efficiency (maximize net economic benefits)	Terrestrial Aquatic Air Human Interface	Real Income Distribution Life, Health, and Safety Educational, Cultural, and Recreational Opportunities Emergency Preparedness Demographic Characteristics Community Organization Other	Income Effects Employment Population Distribution Economic Base and Stability Environmental Effects of Regional Concern Regional Effects on Education, Culture, and Recreation Opportunities

Table 5

Critical Variables Associated with NED Account*

I. Beneficial
   A. Increased output
      1. Flood control
      2. Water supply (municipal and industrial)
      3. Irrigation
      4. Recreation
      5. Navigation
      6. Water quality
      7. Power
      8. Fisheries production
      9. Other
   B. External economies
   C. Value of output from unemployed or underemployed resources

II. Adverse
   A. Value of construction and operation and maintenance
   B. External diseconomies

* All categories to be measured in dollars. No weighting of individual categories should be employed.

Table 6

Critical Variables Associated with EQ Account

Terrestrial

I. Habitat/Land Uses
   A. Habitat type (Example: upland forest)
      1. Habitat subtype (Example: pine forest)
         (a) Quantity
         (b) Quality
      2. Habitat subtype

   B. Habitat type

II. Land Quality/Soil Erosion

III. Critical Community Relationships

IV. Threatened and/or Endangered Species

V. Pests

Aquatic

I. Habitat
   A. Habitat type A
      1. Habitat subtype A1
         (a) Quantity
         (b) Quality
      2. Habitat subtype A2

   B. Habitat type B

II. Water Quality
   A. Physical

   B. Chemical

   C. Bacteriological

III. Water Quantity

IV. Critical Community Relationships

V. Threatened and/or Endangered Species

VI. Pests

Air

I. Quality
   A. Gases

   B. Particulates

II. Climatology

Human Interface

I. Esthetic

II. Historical

III. Archeological

Table 7

Critical Variables Associated with SWB Account

I.	Real Income Distribution
	A. Income generated
	B. Contributions
II.	Life, Health, and Safety
	A. Risk
	B. Pathogens
	C. Noxious effects
III.	Educational, Cultural, and Recreational Opportunities
	A. Amenities
	B. Opportunities
IV.	Emergency Preparedness
	A. Resources
	B. Spatial distribution
V.	Demographic Characteristics
	A. Population
	B. Vital rates (migration)
VI.	Community Organization
	A. Cohesion
	B. Employment mix
	C. Displacement
VII.	Noise
VIII.	Esthetic Values

Table 8

Critical Variables Associated with RD Account

I.	Income Effects
	A. Value of outputs
	B. Value of underemployed or unemployed resources
	C. User payments
	D. Increases from induced or stemming activities
	E. Increases from construction and operation and maintenance activities
	F. Losses from displaced regional activities
	G. Losses of assistance and welfare
	H. Indirect increases in public expenditures
II.	Employment
	A. Long-term
	B. Short-term
III.	Population Distribution
	A. Total population
	B. Composition
IV.	Economic Base and Stability
V.	Environmental Effects of Regional Concern
VI.	Regional Effects on Education, Cultural, and Recreational Opportunities

indicators and elaboration of their meaning and measurement. The lists of variables in Tables 5-8 and Appendix C are evolutionary and subject to continuous updating based on subsequent legislation and/or regulations, experience, and the development of additional impact prediction and assessment techniques.

43. Critical variables should be addressed in every stage in the planning process, even if only to indicate that they are not impacted. It should be noted that these variables are subject to change as a result of new legislation, regulations, and expanding knowledge of the impacts of water resources projects. Selection of the noncritical variables for use in an assessment should involve consideration of the totality of the anticipated impacts. Such variables should be selected based on the composite professional judgment of the interdisciplinary team and the input of others who are knowledgeable and concerned about resources, amenities, and problems of the area.

44. There are no specific guidelines regarding the number or type of noncritical variables that must be addressed in an impact assessment. However, several questions can be used to aid in selecting these variables:

- a. Will any of the alternatives have an impact on the variable?
- b. Will the variable exert an influence on construction scheduling or subsequent operation of any alternative?
- c. Is the variable a matter of significant public concern or controversy?
- d. Do certain cumulative-type impacts mandate inclusion of the variable?

45. The weighting portion of the weighted rankings technique can also be used by the interdisciplinary team to identify noncritical variables for inclusion in the analysis. A list of potential noncritical variables is prepared and subjected to the weighting procedure as described in paragraph 28. The interdisciplinary team then compares each variable with every other variable and assigns values.

46. The decision as to which variable is more important in each pairwise comparison should be based on the collective professional judgment of the interdisciplinary team. Information gained through

public participation and coordination with other agencies should be a major input into the decision process, particularly in determining relevant variables for the study area. Interactive or cross-impact variables can also be considered. Several iterations through the pairwise comparisons may be necessary to ensure consistency in the rationale used in this application procedure. Documentation of the rationale for each decision will be beneficial as the study progresses and evolves. Following the development of the RIC's, the interdisciplinary team could choose to include only the high-priority variables in the study, or they could include all listed ones with less emphasis given to the low-priority variables.

47. Environmental inventory. Compiling baseline information on assessment variables is necessary to form a basis for impact assessment. Sufficient information is required to provide decisionmakers and reviewers an understanding of planning needs, pertinent area characteristics, and relevant variables for consideration in plan formulation and later impact assessment and evaluation.

48. During the plan-of-study stage (Stage 1) of the planning process, assembling baseline information should enable a gross appraisal of the study area. It is anticipated that both the number of variables and the baseline information assembled would increase as progression is made through Stages 2 and 3. The weighting portion of the weighted rankings technique could be used during each stage to assist in determining which variables should be added or deleted.

49. During each stage of the planning process, it is necessary to identify data deficiencies and determine if a data-gathering program needs to be initiated to establish or refine baseline information. The weighting portion of the weighted rankings technique can also be used to allocate limited manpower and monetary resources to those variables for which data should be collected. An example of using the technique for this purpose is presented in Table 9. In the case illustrated in Table 9, Q dollars are available for baseline studies and are to be allocated to five variables. As was the case for the example in paragraph 28, a dummy variable (V6) is included to preclude the final

Table 9

Application of the Weighted Rankings Technique to the Allocation of Planning Resources

Variable	Assignment of Weights															Sum	RIC	Relative Costs* for Baseline Studies	RIC × Relative Cost	Cost-Weighted RIC**
V1	0	1	1	0	1											3.0	0.20	1	0.20	0.11
V2	1					1	1	1	1							5.0	0.33	2	0.66	0.36
V3		0				0				1	0	1				2.0	0.13	4	0.52	0.29
V4			0				0			0			0.5	1		1.5	0.10	2	0.20	0.11
V5				1				0			1		0.5		1	3.5	0.24	1	0.24	0.13
V6 (Dummy)					0				0			0		0	0	0	0	0	0	0
															Total	15.0	1.00		1.82	1.00

* Relative costs would be based on field experience. In this example it is estimated that V1 and V5 are the least expensive to collect and V3 is the most expensive.

** These decimal fractions can be used in the proportionate allocation of limited resources.

assignment of an RIC of zero to any variable. As was done in the example in paragraph 28, pairwise comparisons are used to determine the RIC's. The RIC values, when multiplied by Q dollars, would yield a possible allocation of monetary resources to baseline studies for variables V1-V5, if data-collection costs are comparable. For example, V1 would be allocated 0.20 Q dollars, V2 would be allocated 0.33 Q dollars, and so on.

50. Table 9 also illustrates how relative data-collection costs can be incorporated into the monetary allocation process. A column is included to show relative costs for baseline studies for each variable. In this example, baseline studies for V3 would be the most expensive, while those for V1 and V5 would be the least expensive. Multiplying these relative costs by the RIC's and proportioning the results yields cost-weighted RIC values. If these cost-weighted RIC's are multiplied by Q dollars, another possible allocation of monetary resources is obtained. If this calculation is performed, V1 would be allocated 0.11 Q dollars, V2 would be allocated 0.36 Q dollars, and so on. Again, documentation of all rationale will be useful as the study progresses and evolves.

51. The allocations as determined by cost-weighted RIC's could be modified by considering interrelationships among variables and timing of data-collection efforts. Although this approach requires additional professional judgment, systematic use of the weighting portion of the weighted rankings technique provides the interdisciplinary team and the study management staff an analytical framework for allocating limited resources.

Impact prediction, assessment, and evaluation

52. WRAM includes prediction and assessment of the changes of each alternative on each variable, and assessment of the implications of these predicted impacts. Assessment involves importance weighting of variables and scaling of impacts. Evaluation includes multiplication of scaled values by RIC's for each variable, and aggregation and professional interpretation of the results. Both objective and subjective activities are involved in impact prediction, assessment, and evaluation.

53. Prediction and delineation. Impact matrices and networks are useful for identifying and displaying potential impacts of alternatives. Qualitative descriptions of impacts have been prepared for reservoirs (Battelle-Columbus Laboratories 1974a, U. S. Environmental Protection Agency 1976a), channelization projects (U. S. Environmental Protection Agency 1976b), and dredged material disposal (Battelle-Columbus Laboratories 1974b). Defining interrelationships among impacted variables is presently very difficult. In addition, precise delineations of secondary impacts are generally not available.

54. The most difficult task associated with impact assessment is the prediction of impact magnitude. Prediction in this context is the attempt to quantify the changes that will occur in variables. Prediction involves use of currently available predictive models (physical and mathematical) and the professional judgment of the interdisciplinary team. Quantitative predictive techniques are available for some variables. For example, the impact prediction techniques described in the Battelle Water Resources Projects method (Battelle-Columbus Laboratory 1974a) and the Battelle Dredging Impact Assessment method (Battelle-Columbus Laboratories 1974b) are primarily related to quantifying changes in various physical, chemical, and bacteriological variables of water quality. For variables that have no scientifically based predictive techniques, the exercise of sound professional judgment by the interdisciplinary team is critical for impact prediction. Development of additional predictive techniques is considered to be beyond the scope of this study.

55. Regardless of whether objective prediction techniques or subjective judgments are used to predict impacts, the interdisciplinary team must be cognizant of the accuracy of the results. Predictions of impacts will always have risk and uncertainty, and the interdisciplinary team must consider these in all eventual trade-off analyses.

56. Other considerations in impact delineation are related to type of effect, location, timing, duration, probability, and reversibility. These are defined as follows:

a. Type of effect. Type I effects are direct, unavoidable consequences of alternative plans and the no-action alternative. Type II impacts are consequences directly related to the intended output of alternative plans. Type III impacts include related induced consequences (ER 1105-2-440).

b. Location. The location is the area expected to be affected by the plan, whether within the planning area, the remainder of the study area, a larger area affected by the plan, or the rest of the Nation.

c. Timing. The timing is the period during which the impact is expected to occur.

d. Duration. The duration is the length of time the impact will affect the location. Short duration is 1-10 yr, while long duration is 10 yr and beyond.

e. Probability. Probability is a numerical expression, not necessarily mathematically computed, that represents technical knowledge and professional judgment as to the likelihood of occurrence.

f. Reversibility. The impact is irreversible or reversible.

57. Weighting and scaling. Two requirements must be met before an impact assessment can be completed. First, RIC's must be assigned to each assessment variable used; secondly, the impacts of the alternatives on each variable must be scaled.

58. The weighting portion of the weighted rankings technique is used in WRAM for the purpose of assigning importance weights to variables. An example of the assignment of RIC's was presented in paragraph 28. The number of assessment variables will probably change during the planning process as increased information becomes available and as new plans are formulated. For example, the number of variables used in Stage 1 will most likely be fewer than the number used in Stages 2 and 3. In addition, the quantity and quality of baseline data and predicted changes will be refined during the planning process. Accordingly, it may be necessary to adjust the RIC's for assessment variables during the planning process.

59. In order to assign importance weights through use of the weighted rankings technique, it is necessary to make the initial allocation among the broad categories within a given account; for example, among the terrestrial, aquatic, air, and human interface categories within the EQ account. A second allocation would be made to the

subcategories within each category, for example, between air quality and climatology in the air category. Additional allocations would be to individual variables.

60. Impact scaling can be accomplished by one of three approaches: (1) use of the scaling portion of weighted rankings technique (presented in Table 2); (2) use of functional curves and proportioning of resulting scaled impacts; and (3) use of linear scaling and proportioning of resulting scaled impacts. An example presented in Appendix D illustrates the mechanics of scaling and weighting.

61. Figure 4 illustrates the use of functional curves for scaling. The range of potential values (a to b) for the Variable M is shown on the X-axis. The Y-axis values range from 0, which is representative of the

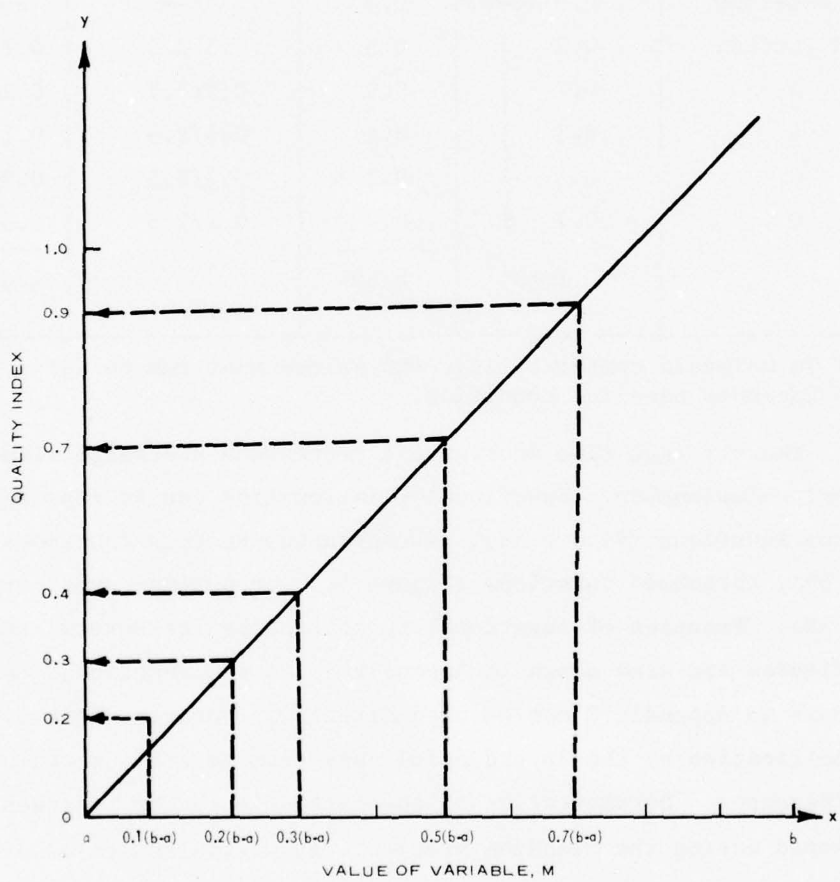

Figure 4. Concept of scaling

least desirable quality, to 1, which is representative of the most desirable quality. The functional relationship depicted between a variable and the quality index is based on technical evidence and/or the collective professional judgment of the interdisciplinary team. Functional curves such as the one shown in Figure 4 would be used to determine the quality index for the current conditions of the variable and predicted conditions resulting from the alternatives. For example, for the values of the variable shown in Figure 4, the quality index for each alternative is illustrated in the following tabulation.

Condition or Alternative	Variable Measurement	Quality Index	Proportioning	ACC*
Baseline	0.3 (b-a)	0.4	--	--
No action	0.2	0.3	0.3/2.5	0.12
A	0.7	0.9	0.9/2.5	0.36
B	0.3	0.4	0.4/2.5	0.16
C	0.5	0.7	0.7/2.5	0.28
D	0.1	0.2	0.2/2.5	0.08
	Total	2.5**		1.00

* To maintain comparability, ACC values must sum to unity.
** Excludes baseline condition.

62. The straight line in Figure 4 represents a straight-line functional relationship. Functional relationships can be represented by continuous functions (Figure 5a), discontinuous or step functions (Figure 5b), threshold functions (Figure 5c), or optimum area curves (Figure 5d). Examples of functional relationships for several assessment variables are also shown in Appendix C. A few functional relationships shown in Appendix C can be used directly. However, most will require modification by the interdisciplinary team to reflect regional or area differences. Documentation of the rationale for any changes should be developed during the planning process. If variables are used for which no function graphs exist, the interdisciplinary team can develop function graphs through use of laboratory or field testing, literature

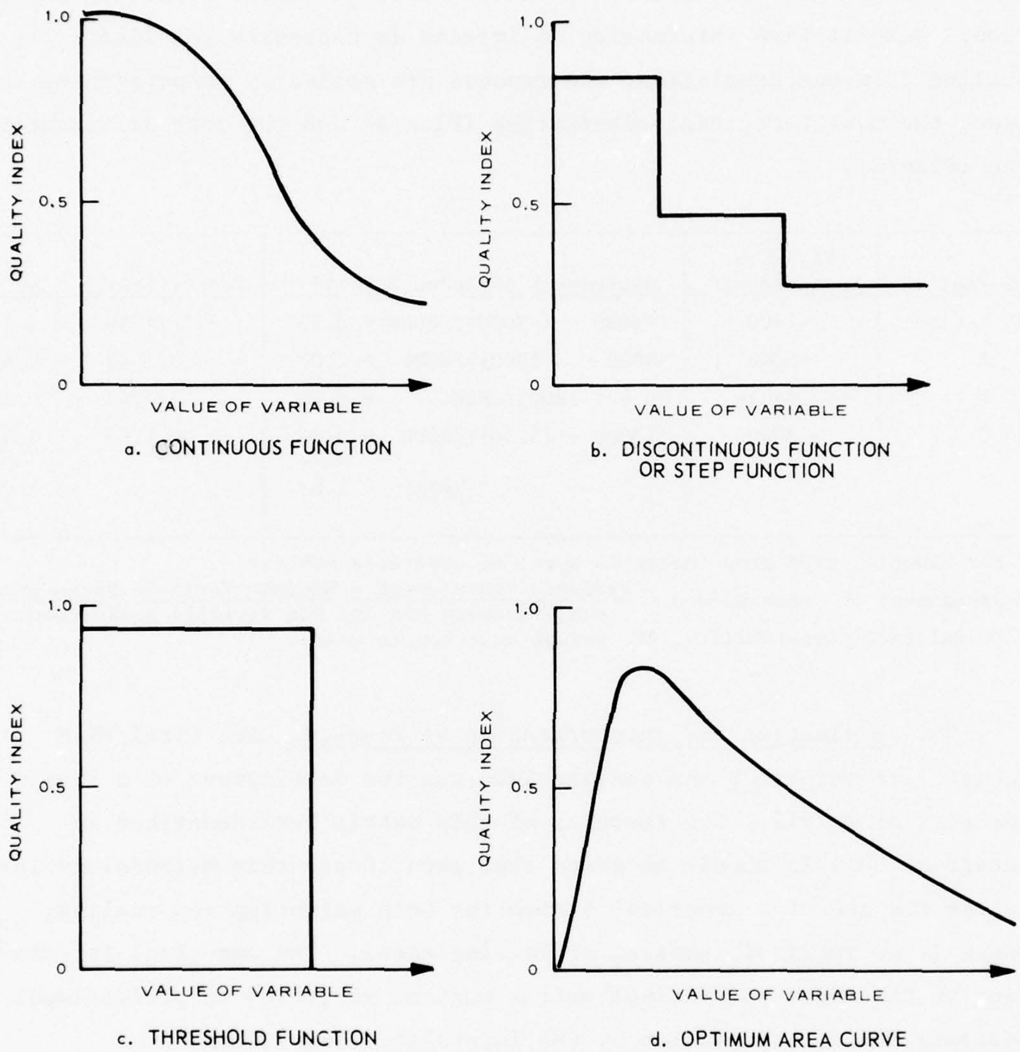

Figure 5. Illustration of types of functional relationships

reviews, and professional judgment.

63. Another technique of scaling the impacts of alternatives on a variable is to use linear scaling between the largest and smallest impacts. An example using this technique is shown in the following tabulation. Quantitative information on impacts is necessary for linear scaling. In the tabulation, the impacts are scaled by proportioning between the most beneficial alternative (Plan A) and the most detrimental one (Plan C).

Alternative	Variable Measurement*	Assignment of Index Value**		Proportioning	ACC†
No action	-1000	[-1000 - (-3000)]/8000	= 0.25	0.25/1.63	0.16
A	+5000	[5000 - (-3000)]/8000	= 1.00	1.00/1.63	0.61
B	No change	[0 - (-3000)]/8000	= 0.38	0.38/1.63	0.23
C	-3000	[-3000 - (3000)]/8000	= 0.00	0.00/1.63	0.00
		Total	1.63		1.00

* For example, predicted change in acres of desirable habitat.

** Assignment of Index Values = $\frac{\text{Variable Measurement - Minimum Variable Measurement}}{\text{Range between Max and Min Variable Measurements}}$

† To maintain compatibility, ACC values must sum to unity.

64. Evaluation and interpretation of results. The final WRAM activity in weighting and scaling involves the development of a final coefficient matrix. The features of this matrix were described in paragraph 33. It should be noted that even though this methodology involves the use of a numerical system for both weighting and scaling, there is no intrinsic passing or failing score. The numerical information in the final coefficient matrix must be subjected to professional analysis and interpretation by the interdisciplinary team.

65. It is also possible to use the weighted rankings technique for comparative evaluation of the four major accounts. This would involve assigning importance weights (RIC's) to the four accounts and scaling each alternative relative to each of the accounts. An example using the weighted rankings technique is presented in Tables 10-12. Table 10 shows RIC's for the alternatives relative to the EQ, NED, SWB,

and RD accounts. Table 11 shows impact information for the four major accounts. These values were developed based on consideration of the EQ and NED accounts as having equal importance, and the SWB and RD accounts as having equal importance but less than the EQ or NED accounts. Table 12 presents the ACC's for each account derived from the information in Table 11 using weighted rankings (the ACC's could also be derived by linear proportioning of the scores from each account's final coefficient matrix). The following is the final coefficient matrix based on Tables 10-12. In this example, the no-action alternative is the most desirable alternative, followed by Plan C.

		ACC of Plan				Final Coefficient Matrix of Plan, RIC × ACC			
Account	RIC	No Action	A	B	C	No Action	A	B	C
EQ	0.35	0.50	0.00	0.33	0.17	0.18	0.00	0.11	0.06
NED	0.35	0.33	0.50	0.00	0.17	0.11	0.18	0.00	0.06
SWB	0.15	0.17	0.33	0.00	0.50	0.02	0.05	0.00	0.08
RD	0.15	0.33	0.00	0.17	0.50	0.05	0.00	0.02	0.08
					Total	0.36	0.23	0.13	0.28

Documentation of results

66. The final component in WRAM is documentation of the analysis. Documentation involves describing the rationale used to select the variables considered in the three planning stages, identify and predict impacts, and assign importance weights to variables and scale impacts. This documentation also needs to address limitations in the process as well as the uncertainties associated with impact prediction. It is important to specify the scaling technique used for each variable, particularly if an existing functional curve is modified or a new relationship developed.

67. Documentation of the analysis should include proper referencing. Lack of referencing may form the basis for criticisms of an analysis that has been accomplished. In conjunction with referencing, it may be desirable to identify general references and specific sources

Table 10

RIC's for Four Accounts*

Account	Assignment of Importance										Sum	RIC
EQ	0.5	1	1	1							3.5	0.35
NED	0.5				1	1	1				3.5	0.35
SWB		0			0			0.5	1		1.5	0.15
RD			0			0		0.5		1	1.5	0.15
Dummy				0			0		0	0	0	0
										Total	10	1.00

* The values developed were based on the WES team's interpretation of philosophy of Principles and Standards; i.e., considering EQ and NED of equal importance, and SWB and RD of equal importance but less important than EQ or NED.

Table 11

Impact Information for Comparison of Alternatives

	Alternative			
Account	No Action	Plan A	Plan B	Plan C
EQ	Most beneficial	Most adverse	Beneficial	Adverse
NED	Beneficial	Most beneficial	Most adverse	Adverse
SWB	Adverse	Beneficial	Most adverse	Most beneficial
RD	Beneficial	Most adverse	Adverse	Most beneficial

Table 12

ACC's for Four Accounts

Account	Alternative	Assignment of Value						Sum	ACC
EQ	No Action	1	1	1				3	0.50
	A	0			0	0		0	0.00
	B		0		1		1	2	0.33
	C			0		1	0	1	0.17
							Total	6	1.00
NED	No Action	0	1	1				2	0.33
	A	1			1	1		3	0.50
	B		0		0		0	0	0.00
	C			0		0	1	1	0.17
							Total	6	1.00
SWB	No Action	0	1	0				1	0.17
	A	1			1	0		2	0.33
	B		0		0		0	0	0.00
	C			1		1	1	3	0.50
							Total	6	1.00
RD	No Action	1	1	0				2	0.33
	A	0			0	0		0	0.00
	B		0		1		0	1	0.17
	C			1		1	1	3	0.50
							Total	6	1.00

of information. Detailed information should appropriately be included in appendixes along with specific impact calculations, with only summary tables included in the text.

68. An important use of the documentation of the analysis is the determination of whether an environmental impact statement is required, as well as to supply information for potential use in other documents that may be associated with the study (e.g., environmental assessment report, survey report, and general design memorandum).

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

69. A review of 54 impact assessment methodologies revealed that none are sufficiently comprehensive for or directly applicable to Corps water resources projects and programs. However, salient features contained in eight of the methodologies were considered pertinent for inclusion in WRAM. The concept of weighting impacted variables and scaling the impacts of alternatives is particularly appropriate since a major difficulty in assessment is an inability to evaluate impacts on a comparable basis. Through the use of weighting and scaling (weighted ranking technique), an interdisciplinary team cognizant of the study area needs, planning objectives, and public preferences can assess variables and evaluate alternatives on a comparable basis.

70. Limitations in the state of the art of impact assessment are reflected in WRAM. Primary limitations include identification of interrelationships between environmental variables, delineation of secondary and tertiary effects, and prediction of impact magnitude. Additional research on the development of functional graphs and on techniques for predicting changes in variables and impacts of alternatives is required. The dynamic character of WRAM will allow the incorporation of new information and technology as it becomes available. Considerable research and development will be required to develop predictive models for variables that must be considered in impact assessment and more specific techniques that address secondary, tertiary, and cumulative impacts. These areas will be investigated in research studies to be conducted over the next four years.

71. In contrast to the limitations described above, WRAM has the following advantages:

- a. Addresses the requirements of Principles and Standards to consider two national objectives, NED and EQ, and to display beneficial and adverse effects of each plan relative to four accounts, i.e., NED, EQ, RD, and SWB.

b. Provides a framework that assists the decisionmaking process based on professional judgment supported by available data, recognizing that decisions must often be made without complete information.

c. Incorporates an interdisciplinary approach for the identification, assessment, and evaluation process.

d. Provides a framework for screening variables, identifying data needs, and allocating limited planning resources.

e. Allows for various levels of detail to be used and decisions made, during the stages in the planning process.

Recommendations

72. Because this is an interim report, the purpose of the recomdations is to identify the following research areas that require further development, testing, and evaluation:

a. WRAM should be field tested on several types of water resources projects.

b. A statistical package for testing the significance of the differences between the weighted-scaled values for alternatives should be developed.

c. A computer program for use of the weighted rankings technique should be developed.

d. A training course based on WRAM should be presented to District personnel prior to their use of WRAM.

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APPENDIX A: STATUTES, EXECUTIVE GUIDELINES, AND APPLICABLE FEDERAL REGULATIONS RELATED TO ENVIRONMENTAL ASSESSMENT

Statutes

1. Fish and Wildlife Coordination Act of 1958 (Pub. L. 85-624), as amended (16 U.S.C. 661 et seq.), 12 August 1958.
2. Clean Air Act of 1963 (Pub. L. 88-206), as amended (42 U.S.C. 1857 et seq.), June 1974.
3. Wild and Scenic Rivers Acts of 1968 (Pub. L. 90-542), 2 October 1968.
4. Federal Water Project Recreation Act of 1965 (Pub. L. 89-72), as amended (16 U.S.C. 668aa-668ee), 9 July 1965.
5. National Environmental Policy Act of 1969 (Pub. L. 91-190, 83 Stat. 852, 42 U.S.C. 4221 et seq.), 1 January 1970, referred to as NEPA.
6. Sections 122 and 209, River and Harbor and Flood Control Act of 1970, Public Law 91-611 (84 Stat. 1818), 31 December 1970.
7. Sections 402 and 404, Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (66 Stat. 816), 18 October 1972.
8. Section 103, Marine Protection, Research, and Sanctuaries Act of 1972, Public Law 92-532 (86 Stat. 1052), 23 October 1972.
9. Title III - Management of the Coastal Zone, Public Law 92-583 (86 Stat. 1280), 27 October 1972.
10. Endangered Species Act of 1973, Public Law 93-205 (87 Stat. 884), 28 December 1973.
11. Sections 1 and 73, Water Resources Development Act of 1974, Public Law 93-251 (88 Stat. 12), 7 March 1974.
12. Preservation of Historic and Archeological Data, Public Law 93-291 (88 Stat. 174), Reservoir Salvage Act of 1960, amending Public Law 86-523 (74 Stat. 220), 24 May 1974.

Executive Guidelines

1. Executive Order 11514, Protection and Enhancement of Environmental Quality, 5 March 1970 (35 F.R. 4247, 7 March 1970).
2. Guidelines for Statements on Proposed Federal Actions Affecting the Environment, Council on Environmental Quality (CEQ), 1 August 1973 (38 F.R. 20550).
3. Water and Related Land Resources; Establishment of Principles and Standards for Planning, Water Resources Council (WRC), 10 September 1973 (38 F.R. 24778 to 24869).

Corps of Engineers Regulations

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2. ER 1165-2-116, Pollution Control at Civil Works Projects, 28 February 1968.
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4. ER 1165-2-500, Environmental Guidelines for the Civil Works Program of the Corps of Engineers, 30 November 1970.
5. ER 1130-2-400, Recreation-Resource Management of Civil Works Water Resource Projects, Changes 1 through 3, 28 May 1971.
6. ER 1105-2-11, Preservation, Restoration, and Administration of Historic and Cultural Environment, Change 1, 15 March 1972 (proposed revision, 40 F.R. 41636, 8 September 1975).
7. ER 1105-2-12, Archeological Investigations and Salvage Activities, 15 May 1972 (proposed revision, 40 F.R. 41636, 8 September 1975).
8. ER 1105-2-13, Aquatic Plant Control Programs, 31 May 1972.
9. ER 1105-2-502, Public Meetings (33 CFR 209.405), 4 December 1972.
10. ER 1105-2-105, Guidelines for Assessment of Economic, Social, and Environmental Effects of Civil Works Projects, 15 December 1972.
11. ER 1105-2-129, Preservation and Enhancement of Fish and Wildlife Resources, 15 August 1973.
12. ER 1105-2-509, Statement of Findings on Impacts of Civil Works Actions, 9 October 1973.
13. ER 1130-2-407, Operating and Testing Potable Water Systems, 18 January 1974.
14. ER 1105-2-507, Preparation and Coordination of Environmental Statements (33 CFR 209.410), 15 April 1974.
15. ER 1105-2-508, Review of Environmental Impact Statements Prepared by Other Agencies, 6 May 1974.
16. ER 1130-2-405, Use of Off-Road Vehicles on Civil Works Projects, 17 January 1974.
17. ER 1105-2-14, Framework and River Basin Study Programs (Level A and Level B Studies), 28 July 1975.
18. ER 1105-2-200, Planning Process: Multiobjective Planning Framework (33 CFR 290), 10 November 1975.
19. ER 1105-2-210, Planning Processes: Plan Development Stages (33 CFR 291), 10 November 1975.

20. ER 1105-2-220, Planning Processes: Problem Identification (Task 1) (33 CFR 292), 10 November 1975.

21. ER 1105-2-230, Planning Processes: Formulation of Alternatives (Task 2) (33 CFR 293), 10 November 1975.

22. ER 1105-2-240, Planning Processes: Impact Assessment (Task 3) (33 CFR 294), 10 November 1975.

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28. ER 1105-2-450, Environmental Considerations: Evaluation of Alternative Plans, December 1976.

APPENDIX B: METHODOLOGIES INITIALLY SCREENED TO DETERMINE THEIR POTENTIAL USE IN WATER RESOURCES PLANNING

Evaluation Factors

Nineteen evaluation factors or selection criteria were used to screen the various impact methodologies listed in this appendix. These factors, stated in the form of questions, follow:

1. Does it identify environmental items?
2. Does it identify potential impacts?
3. Does it tell how to measure impacts?
4. Is it able to predict potential impacts (short-term and long-term)?
5. Can it interpret the impacts?
6. Is it responsive to Corps environmental guidelines?
7. Is it practical for use in routine field cases (i.e., cost, ease of manipulation, data requirements)?
8. Is there flexibility built in the system so that it can be used for different types of projects (i. e., construction, operation and maintenance, flood control, etc.)?
9. Is the system reliable?
10. Does it highlight major or key issues?
11. Does it tell how to determine predicted change or impact (i.e., scale or magnitude)?
12. How applicable is the methodology to projects of widely different scale?
13. Is there potential for public involvement?
14. What is the degree of objectivity versus subjectivity?
15. Does it display trade-offs?
16. What are the attractive features for Corps projects?
17. What special skills are required of users of the method?
18. What are the limitations of the methodology?
19. Are examples available that document its successful use?

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APPENDIX C: A LIST OF VARIABLES FOR CONSIDERATION IN DETERMINING POTENTIAL IMPACTS OF WATER RESOURCES PROJECTS

Only Selected Examples of the Variables Are Presented at This Time for Your Review and Comment.

Introduction

Included in this appendix are examples of variables or indicators associated with the National Economic Development (NED), Environmental Quality (EQ), Social Well-Being (SWB), and Regional Development (RD) accounts. This list is not considered to be all-inclusive, nor is it meant to be such. The Final Report, to be published after this methodology is field tested, will include a comprehensive list and description of factors to be considered by planners and decisionmakers. In this Interim Report, however, several examples of variables for each account are presented with their definitions and suggestions for measurement. The structure of each account is shown in Figures 1-4, respectively, preceding the examples of the variables for each account. A table of factors for converting metric (SI) units of measurement to U. S. customary units and U. S. customary units to metric (SI) units is given on page 7.

It should be recognized that as the state of the art in impact assessment advances, the variables used and methods of measurement and prediction may also change. Consequently, this appendix will require periodic revision.

Contents

List of Figures

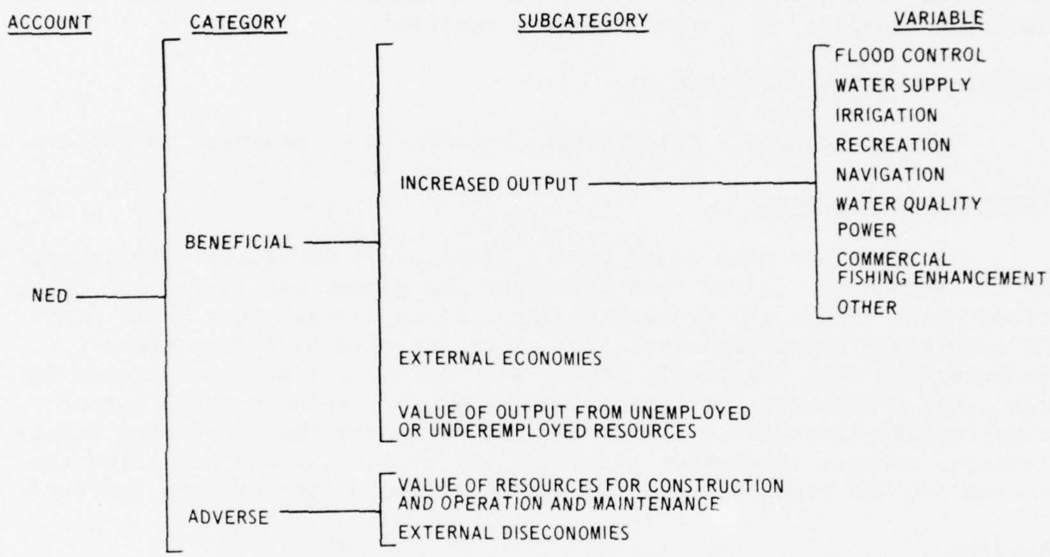


Figure C1. Structure of the National Economic Development account

Account: National Economic Development

Category: Beneficial

Subcategory: Increased Output

Variable: Flood Control

Definition and Measurement

Flood-control benefits are defined as an increase in the productivity of land or a reduction in the cost of using land resources through implementation of a floodplain management plan. NED benefits are categorized according to their effect on activities such as inundation reduction benefits (including soil erosion and sedimentation), location benefits, or intensification benefits.

Functional Curve and Rationale

None to be used. All NED benefits are to be measured in dollars.

Prediction of Impacts

Floodplain zoning could have a significant beneficial NED impact by (a) helping to ensure that efficient and proper use is made of flood-prone lands; (b) preventing large flood damages that would occur if unsuitable development were to occur; (c) eliminating or sharply reducing the need for local, State, and Federal relief expenditures in the event of floods; (d) eliminating or sharply reducing the cost of constructing large-scale floodwater control works that sometimes merely transfer damages to another area; and (e) preserving and enhancing the recreation and fish and wildlife values of the region or area involved.

Remarks

From Principles and Standards (Water Resources Council 1973) and Bureau of Reclamation (1972). See CE ER 1105-2-351 and Soil Conservation Service Economics Guide (especially Chapter 5, "Erosion and Sediment," Soil Conservation Service 1964).

Account: National Economic Development

Category: Beneficial

Subcategory: External Economies

Definition and Measurement

Increased output of individual firms or industries directly affected by a plan may enable related firms or industries to take advantage of more efficient production techniques, or may indirectly affect consumers. Such productivity changes or technological external economies can be attributed as a benefit to a plan. For example, higher levels of output by directly affected firms may enable subsequent processing firms to use more efficient processing techniques and thereby release resources for use in producing other goods and services or permit the higher level of output to be processed with no additional resources.

Functional Curve and Rationale

None to be used. All NED benefits to be measured in dollars.

Prediction of Impacts

Present techniques are not well developed for measuring the beneficial effects accruing from external economies. However, in situations where it is thought that the increased output of final consumer goods or intermediate goods used by direct users can be expected to increase the productivity or output of related firms, an attempt should be made to measure the net income change resulting from such externalities. When this is done, the methodology should be carefully documented in the report.

Remarks

From Principles and Standards (Water Resources Council 1973). See also Bureau of Reclamation (1972).

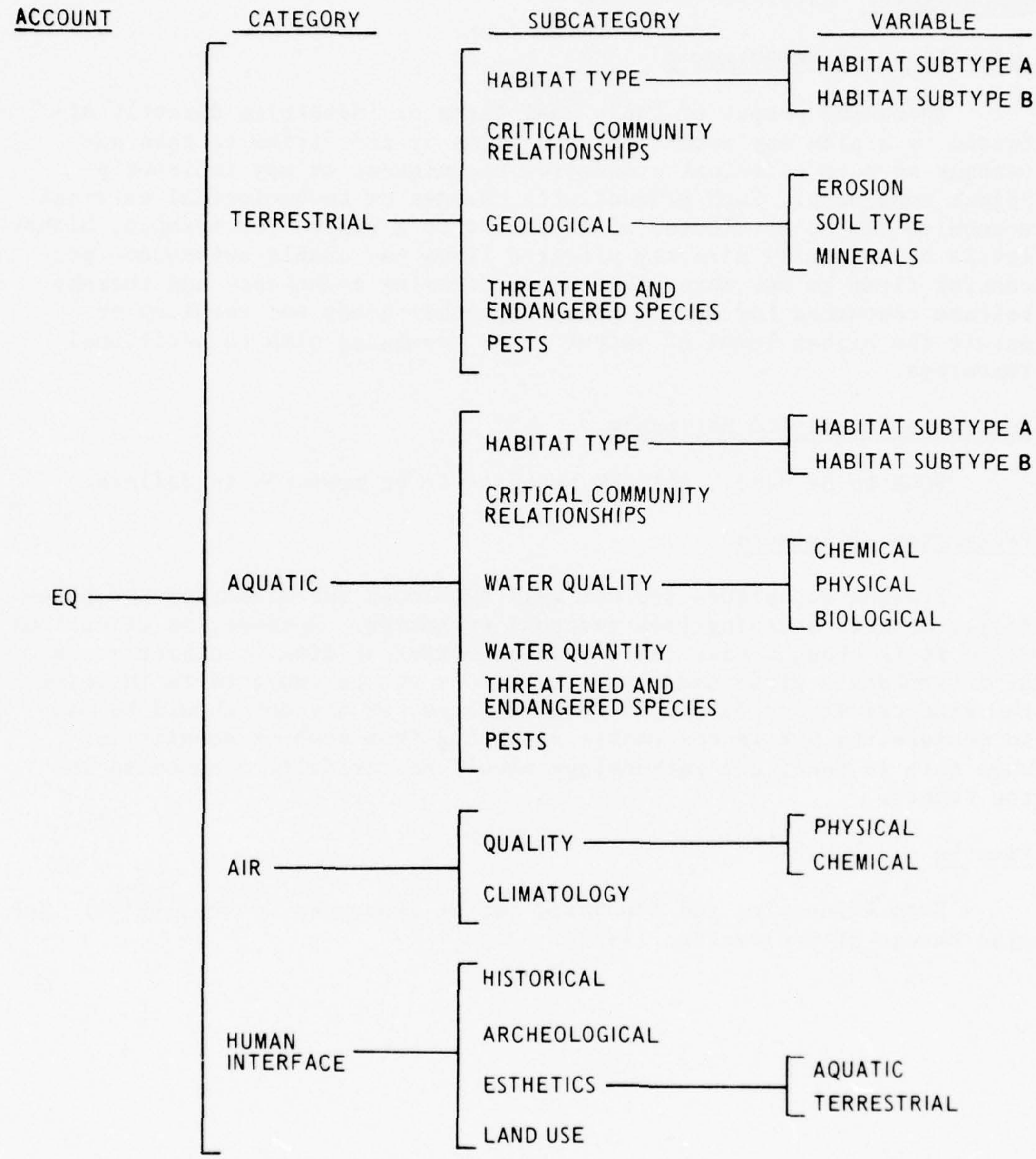


Figure C2. Structure of the Environmental Quality account

Account: Environmental Quality

Category: Human Interface

Subcategory: Esthetics (Biota)

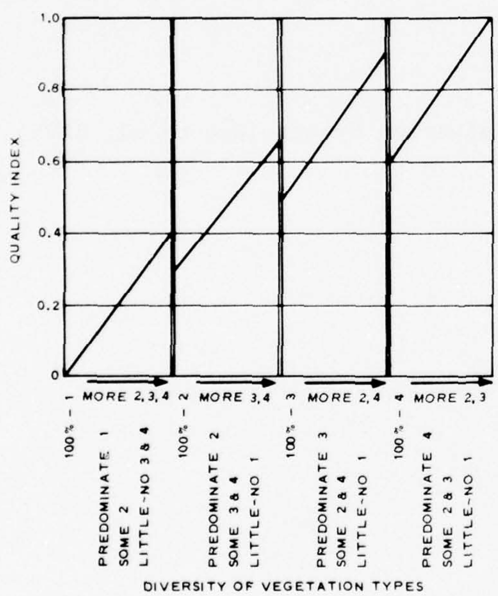
Variable: Diversity of Vegetation Types

Definition and Measurement

The esthetic quality of a site is a function of its types of vegetation and the proportions of the different types to one another.

Trees are generally considered the most visually pleasing vegetation type, and cultivated (irrigated) crops slightly less so. Low shrubs, grass, and dry farming are collectively rated somewhat lower than these, and the absence of vegetation is considered the least pleasing. Diversity rather than uniformity is desirable; for example, land predominantly in trees, but with a mixture of vegetation types, is rated higher than land with a 100-percent tree cover. Measurement involves determining the proportion of trees, crops, shrubs and grasses, and no vegetation in the project area.

Functional Curve and Rationale



NOTE: EVALUATE TO APPROX. 1/2 MILE HORIZONTALLY BEYOND SHORELINE OF PROPOSED RESERVOIR.

WHERE TYPES ARE EQUAL AND THERE IS NO PREDOMINANCE, USE HIGHEST CATEGORY.

PREDOMINATING VARIETIES:
TYPE 1 NO VEGETATION
TYPE 2 LOW SHRUBS, GRASS, DRY FARMING
TYPE 3 CULTIVATED (IRRIGATED) CROPS
TYPE 4 TREES

Prediction of Impacts

To rate a particular site on diversity of vegetation types, only one of the four sections of the value function is used. The evaluator chooses the one labeled with the type of vegetation that, in his judgment, predominates on the site. For example, if the plant cover is 45 percent low shrubs, grass, or dry farming; 35 percent trees; and 20 percent unvegetated, the curve corresponding to vegetation type 2 is used. (Percentages should be estimated.)

If two or more vegetation types on the land to be evaluated are equally distributed, the curve corresponding to the highest category of plant material present is used. In other words, if the plant cover were one-third grass and one-third both trees and cultivated crops, then the type 4 curve would apply.

The proportion of vegetation types on the site other than the predominating type is determined. Different types interspersed on the same area of land requires careful judgment. The greater the amount of vegetation other than that of the predominating type, the higher the rating.

Here again, judgment must be exercised. For example, if cultivated crops predominate on a site and trees cover the remaining land, the site should be given a higher rating than an area where cultivated crops predominate and the rest is in grass or dry farming. The evaluator should take into account the different values of the nonpredominating vegetation types.

Remarks

From *Battelle Environmental Evaluation System* (Dee et al. 1972).

Account: Environmental Quality

Category: Human Interface

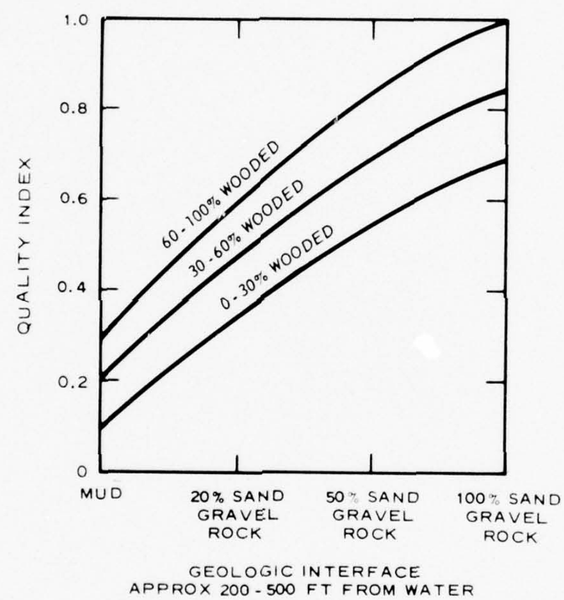
Subcategory: Esthetics (Water)

Variable: Wooded and Geologic Shoreline

Definition and Measurement

Sand, gravel, and rock are generally considered the most visually pleasing geologic materials for the edge of a stream or lake, while unvegetated fine soil or mud usually detracts from the scene. The presence and abundance of trees and shrubs near the shore provide a textured vertical element to define the shoreline, creating a more interesting interface between land and water.

Functional Curve and Rationale



Both the wooded and the geologic aspects of the shoreline are measured in the value function. Although percentages are stated for the amounts of wooded and geologic shoreline, these percentages should be estimated by the evaluator.

Prediction of Impacts

No predictive models are available.

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972).

Account: Environmental Quality

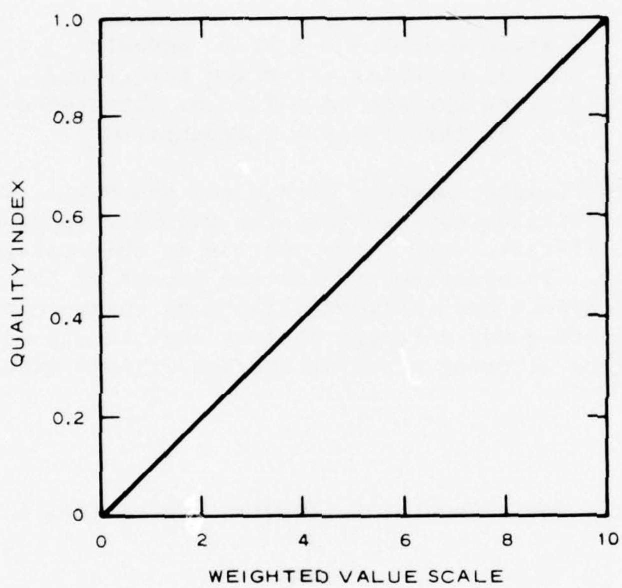
Category: Terrestrial

Subcategory: Threatened and Endangered Species

Definition and Measurement

Species that are uncommon, threatened, or endangered are particularly sensitive to changes in the quality of the environment. A means for assessing the change in population of any species within the project boundaries is needed to determine the environmental impact of proposed projects. Measurement involves consideration of the extent to which the species is threatened or endangered.

Functional Curve and Rationale



The quality index decreases as the extent to which the species is threatened or endangered increases. The status of a species is classified as one of six categories, each of which is assigned a weight:

Category	Weight
Common	10
State endemic	9
U. S. endemic	7
State threatened	5
U. S. threatened	3
Endangered	1

State endemic species are those found only in a single area within the state, although they may be found in other states. They are common in that one location where they are found. A species classified as state threatened or endangered may occur in several locations within the state, but the total numbers of the species are small. It may be found in greater numbers in other states. The least common category (smallest weight) found within the project boundaries is used as the value for the variable even if higher categories are also found:

$$\text{Variable estimate} = \text{Weight of lowest (least common) species}$$

For example, if both an endangered species and a U. S. endemic species occur, the value of the lowest category, 1, is used. In cases where there are more than one species within the lowest category, an additional classification system is used:

3 state endemics = 1 U. S. endemic
3 U. S. endemics = 1 state threatened
3 state threatened = 1 U. S. threatened
3 U. S. threatened = 1 endangered

For example, if the lowest category within the boundaries is the state threatened and it contains two species, the variable value by interpolation would be 4. If there were three species in this category, the variable would equal 3. In order to predict the impact of the proposed project, both the direct and indirect effects on these species must be examined. Construction may directly destroy individuals or may damage their habitats, thus altering breeding success or some other critical life component.

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972).

Account: Environmental Quality

Category: Aquatic

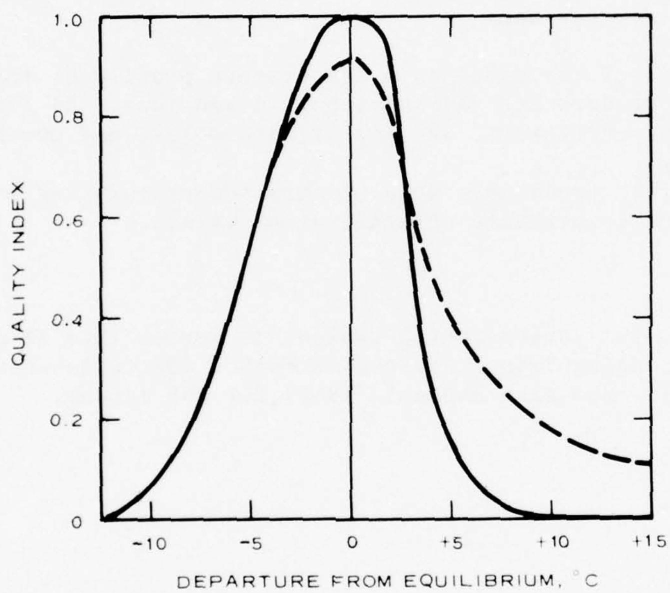
Subcategory: Water Quality

Variable: Water Temperature

Definition and Measurement

Water temperature is important primarily because of the sensitivity of fish and aquatic life to temperature changes. Although each species has an optimum temperature range, aggregate temperature effects are best handled not in terms of temperature per se, but in terms of the magnitude of departure from natural conditions.

Functional Curve and Rationale



The National Sanitation Foundation (NSF) value functions for temperature are shown in the functional curve. In accord with observations for most fish, both value functions imply less serious effects for temperature changes that cool the natural environment than for those that warm it.

Prediction of Impacts

Temperature prediction in rivers and estuaries involves a complete heat balance of the body of water, which accounts for all heat initially present in the water and all heat that flows into and out of the water body during an interval of time. The general time rate of temperature change is given by Raphael (1962):

$$\frac{dt_w}{d\theta} = \frac{Q_t A + m_i(t_i - t_w)}{m_w}$$

where

t_w = river water temperature

θ = time

Q_t = total net heat transfer/area

A = area

m_i = inflow mass of water

t_i = inflow temperature of water

m_w = river water mass

The output of the model is a temperature profile of the stream. The primary input data are (a) water body dimensions, (b) flow and temperature characteristics, and (c) climatological and weather data.

The model is applicable in a uniform temperature region and not applicable where temperature stratification exists.

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972) and Battelle Dredging Impact Assessment Method (Battelle-Columbus Laboratories 1974). See also Raphael (1962) for NSF curves.

Account: Environmental Quality

Category: Aquatic

Subcategory: Water Quality

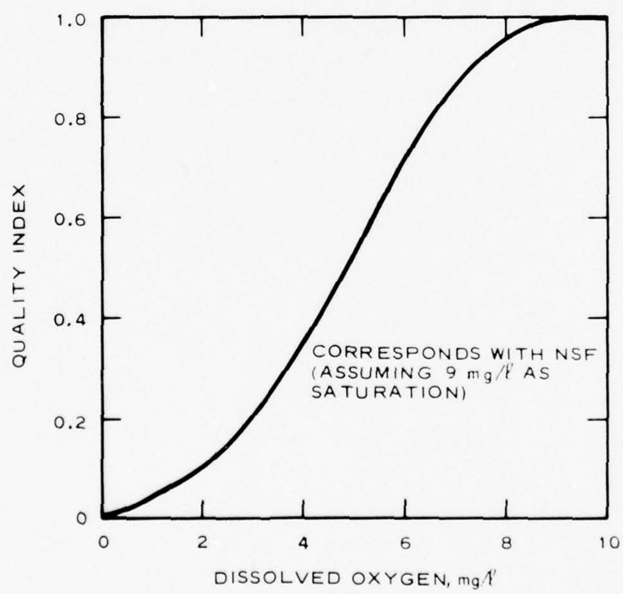
Variable: Dissolved Oxygen

Definition and Measurement

Dissolved oxygen is perhaps the most commonly employed variable of water quality. Low levels of dissolved oxygen adversely affect fish and other aquatic life, and the total absence of dissolved oxygen will lead to the development of an anaerobic condition with the attendant odor and other esthetic problems.

The saturation concentration of dissolved oxygen in water depends on water temperature and on dissolved solids content; the ability of water to hold dissolved oxygen decreases with increases in temperature or dissolved solids. Further, increased temperatures increase the rates at which dissolved oxygen is depleted by the life processes of fish and aquatic life and by the stabilization of biochemical oxygen demand materials.

Functional Curve and Rationale



The oxygen requirements of fish vary with the species and age of the fish. Cold-water fish seem to require higher oxygen concentrations than do the coarse fish (e.g. carp and eel), probably because the former are more active and predatory.

Notwithstanding these variations, it may be stated that the range of 3-6 mg/ℓ is the critical level of dissolved oxygen for nearly all fish. Below 3 mg/ℓ, further decreases in oxygen are important only insofar as the development of local anaerobic conditions is concerned; the major damage to fish and aquatic life will already have been done. Above 6 mg/ℓ, the major advantage of additional dissolved oxygen is as a reserve or buffer to handle shock loads of high oxygen-demanding waste loads. These factors are reflected in the S-shape of the value function. The value function shown in the curve is identical with the one published by the National Sanitation Foundation (NSF) if one assumes a saturation concentration of 9 mg/ℓ (the NSF value function was constructed in terms of percent saturation instead of absolute dissolved oxygen concentration).

Prediction of Impacts

Many predictive models exist for determining changes in dissolved oxygen. A notable source is Nemerow (1974).

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972). See also Battelle Dredging Impact Assessment Method (Battelle-Columbus Laboratories 1974).

Account: Environmental Quality

Category: Aquatic

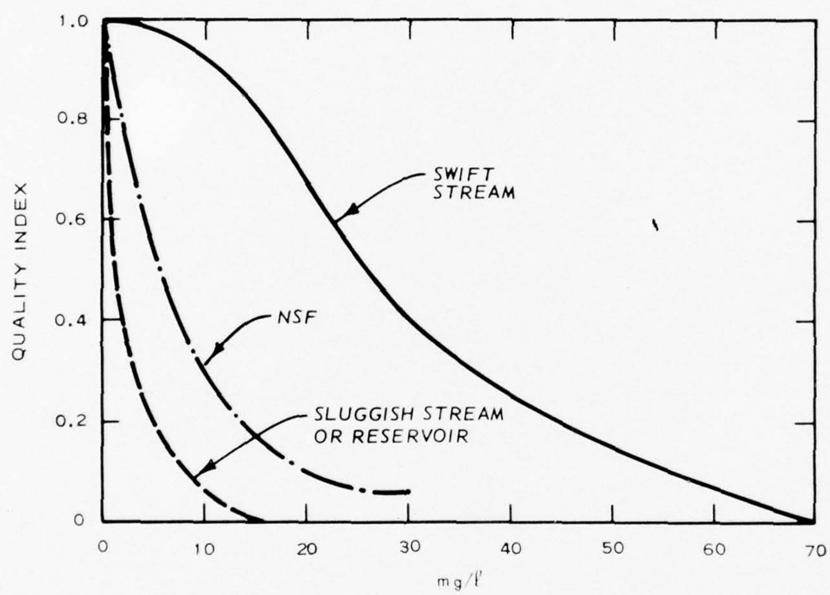
Subcategory: Water Quality

Variable: Biochemical Oxygen Demand

Definition and Measurement

Biochemical oxygen demand (BOD), one of the most widely used variables of water quality, is a surrogate indicator of the effect of a combination of substances and conditions. Specifically, BOD is a measure of the amount of dissolved oxygen that will be depleted from water during the natural biological assimilation of organic materials.

Functional Curve and Rationale



BOD is important only insofar as it promotes the depletion of dissolved oxygen or the growth of undesirable benthic organisms. In a slow, sluggish stream or reservoir, a BOD of 5 mg/ℓ might be sufficient to produce undesirable conditions, whereas a swift mountain stream might easily handle 50 mg/ℓ of BOD without significant deleterious effects. Swift-moving streams have a greater capacity for reaeration and for preventing the accumulation of high BOD materials in bottom deposits than do sluggish streams or reservoirs. Thus, the value function for BOD must be structured to reflect these differences. It is seen that the National Sanitation Foundation (NSF) value function falls in between the value functions provided in the curve for the two extreme conditions described previously. The value function for the sluggish stream or reservoir is characterized by a much more sudden decrease in quality per unit of additional BOD than is the value function for the swift stream.

Prediction of Impacts

Many predictive models are available. See Nemerow (1974).

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972).

Account: Environmental Quality

Category: Aquatic

Subcategory: Habitat and Communities

Variable: Freshwater Nonriver Swamp

Definition and Measurement

Freshwater nonriver swamps are considered to serve as plant and animal habitat. Evaluation of this habitat type is based on composite of five key variables as follows: species associations, percent forest cover, percent flooded annually, ground cover diversity, and percent coverage by ground cover. For definitions of these variables see the variable Freshwater River Swamp.

Functional Curves and Rationale

A curve is provided for each of the five variables. The importance weights for the five variables for freshwater nonriver swamps are as follows:

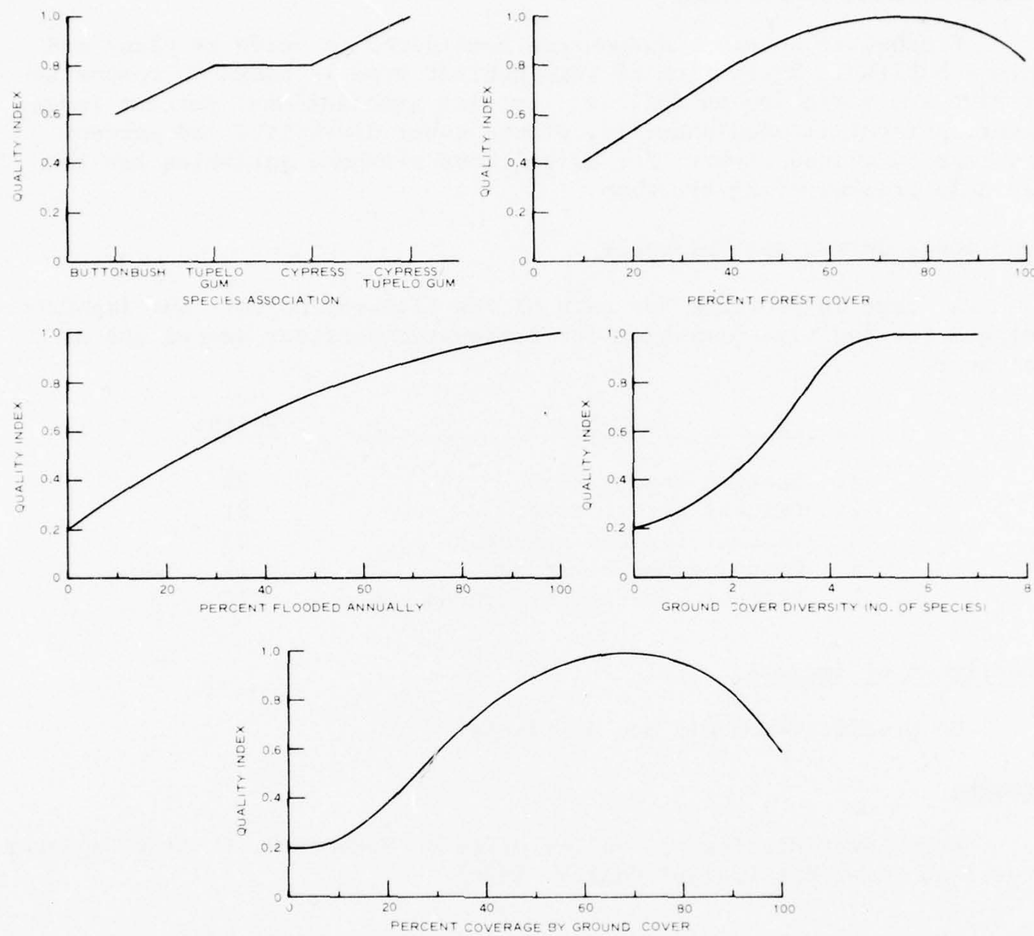
Variable	Weight
1. Species associations	28
2. Percent forest cover	21
3. Percent flooded annually	23
4. Ground cover diversity	14
5. Percent coverage by ground cover	14

Prediction of Impacts

No predictive models are available.

Remarks

From Lower Mississippi Valley Division Method (U. S. Army Engineer Division, Lower Mississippi Valley, 1976).


QUALITY INDEX
SPECIES ASSOCIATION
BUTTONBUSH
TUPELO GUM
CYPRESS
CYPRESS TUPELO GUM
PERCENT FOREST COVER
PERCENT FLOODED ANNUALLY
GROUND COVER DIVERSITY (NO. OF SPECIES)
PERCENT COVERAGE BY GROUND COVER

Account: Environmental Quality

Category: Air

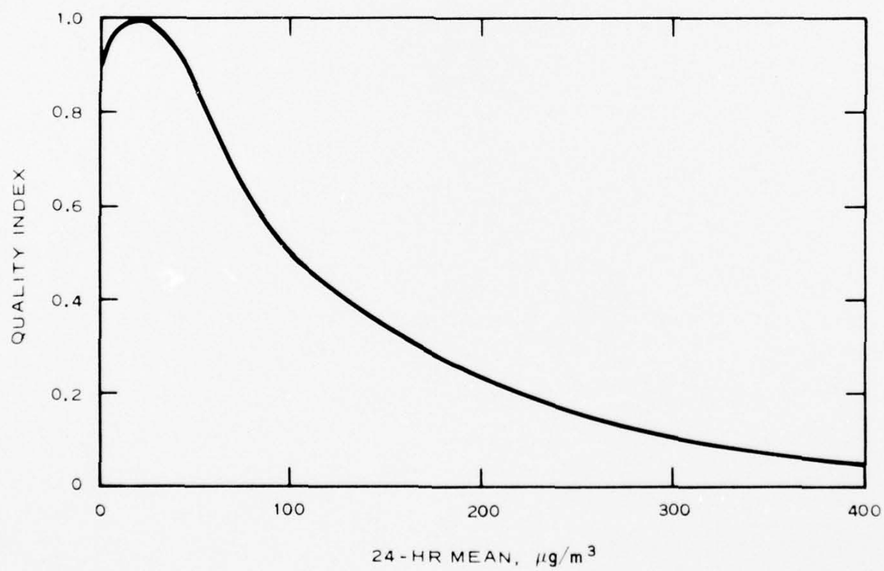
Subcategory: Air Quality

Variable: Particulate Matter

Definition and Measurement

Suspended particulate matter, often referred to as particulates in the air pollution literature, is the most prevalent atmospheric pollutant. Most observations of particulate concentration are obtained with equipment that preferentially collects particles in the 1- to 10-μ range. Larger particles tend to settle out of the air due to gravity and are thus mostly a nuisance. Particles smaller than 1 μ, on the other hand, are most readily respirable and contribute the most to reduction of visibility due to their light-scattering ability. However, most of the literature, criteria, and standards have reference to 1- to 10-μ particles, the concentration of which is expressed as mass per unit volume, usually micrograms per cubic metre.

Functional Curve and Rationale



A value function for these particulates has been constructed giving consideration to established air quality standards and the criteria upon which the standards are based. In general the function declines relatively steeply as concentrations become great enough to cause noticeable turbidity or to contribute to corrosion of materials. It will decline more slowly at higher concentrations where health effects begin to appear, but will certainly be very low at typical urban concentrations. The value function declines again as concentration approaches zero because some particles are necessary to provide condensation nuclei upon which fog and cloud droplets can form.

Prediction of Impacts

Determine changes in particulate matter levels. Several predictive techniques are discussed in U. S. Environmental Protection Agency (1973) and Seinfeld (1973).

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972).

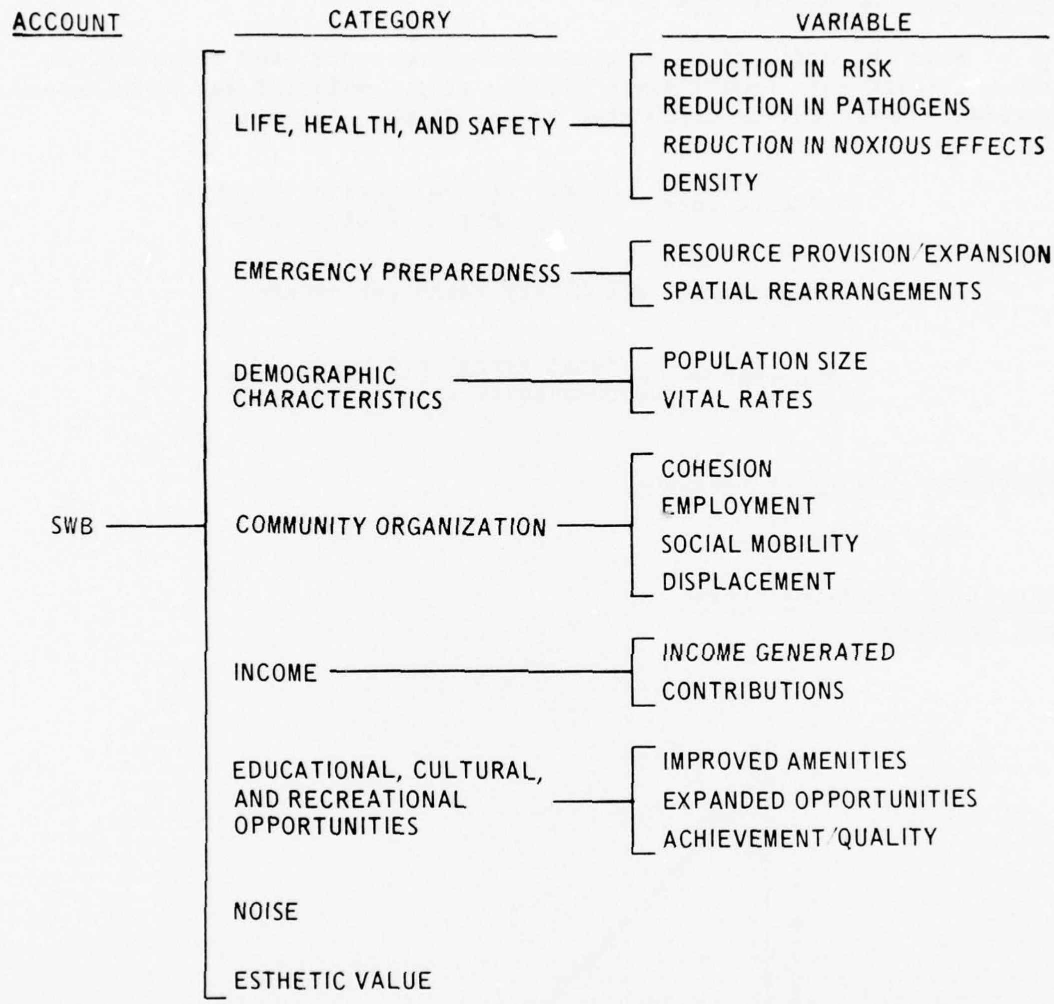


Figure C3. Structure of the Social Well-Being account

Account: Social Well-Being

Category: Life, Health, and Safety

Variable: Reduction in Pathogens (Morbidity)

Definition and Measurement

From the definitions of a cluster of concepts, the reduction in the morbidity rate from a given disease (e.g., malaria) may be selected. Morbidity rates can be calculated as one of the following:

$$\text{Incidence rate} = \frac{\text{number of new cases of disease}}{\text{population of study area}}$$

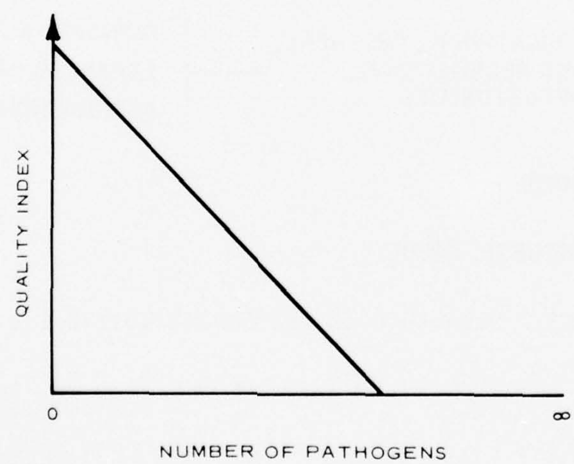
$$\text{Duration} = \text{disability rates per person}$$

$$\text{Severity} = \frac{\text{fatal cases of disease}}{\text{reported total cases of disease}}$$

Functional Curve and Rationale

None avaliable.

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts reflect the removal of pathogens from the environment and the overall improvement of life conditions.

Remarks

Public health statistics.

Account: Social Well-Being

Category: Life, Health, and Safety

Variable: Reduction in Risk

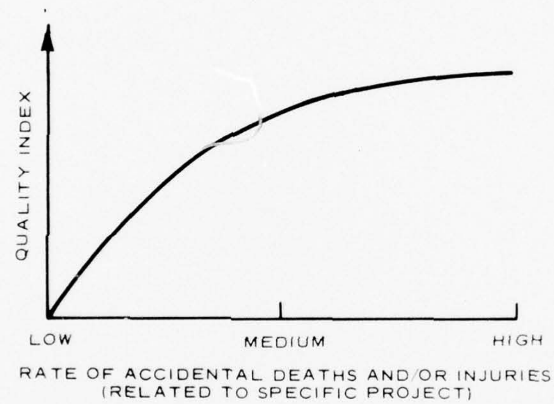
Definition and Measurement

A key variable in determining social well-being is accidental deaths attributed to a project. The measurement can be derived from the general relationship of the number of accidental deaths and/or injuries per 1000 population. It could be further elaborated to reflect mortality rates for specific groups, morbidity rates for selected causes, and severity rates (length of incapacitation).

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Adverse impacts are identified with a significant number of deaths and/or injuries attributed to a specific project. While the term "significant" is relative, it reflects concern with the rate of death, injury, and/or physical malady that affect collective well-being as well as the delivery of health-care services.

Remarks

Most measurements for this variable reflect concern with physical dimensions, such as removal of hazards, expected damages, and safe drinking water. Data for accidental deaths can be obtained from the Federal and State vital statistics, including hospital records.

Account: Social Well-Being

Category: Emergency Preparedness

Variable: Spatial Rearrangements

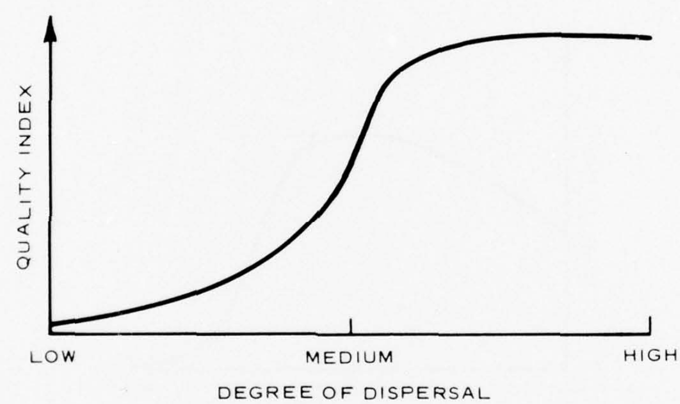
Definition and Measurement

This variable attempts to relate the degree of population and industry dispersal in order to meet a variety of exigencies. Ideally, water resources projects for new towns and industries outside major population centers should be indicators of whether national security demands are being met and of readiness in case of emergency. The Bureau of Reclamation (1972) includes the following factors in this area: provision of flexible reserves of water and protection of waterways.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts accrue where alternative dispersed water systems are able to pick up functions following any national emergency. However, preparedness beyond a certain point of dispersal (intermediate?) may be economically undesirable. Use of gravity models can help determine either concentration or decentralization optima.

Remarks

Standard census sources are useful, as are inventories of project sites. Department of Defense data (as for reaction to potential nuclear attack) may be useful parallel material.

Account: Social Well-Being

Category: Demographic Characteristics

Variable: Population Density

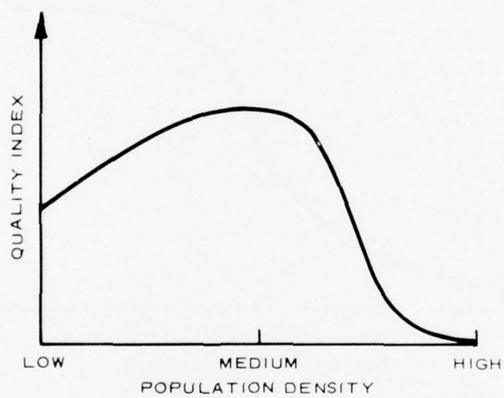
Definition and Measurement

This variable essentially involves the number of people living in a given area. It attempts to measure both the scale of life with regard to the number of affected groups in a given area and the costs associated with various rates of increase in density (such as tax base, crime, opportunities, and discomfort). It is measured by number of people per given area, and while numerical, has no actual reference to what is low or high.

Functional Curve and Rationale

None available.

Idealized Functional Curve
and Rationale



Prediction of Impacts

Presumably, low as well as high densities may contribute to social problems. In the first case, there is no economy of scale and limited opportunities may motivate out-migration. In the latter, high concentrations and crowding produce frustration, noise, and other complications. Yet, high densities may attract new industries and people, accentuating economic opportunities, even limiting congestion in other areas, e.g., national policy for deconcentration, relief of eastern congested areas, and metropolitan sprawl.

Remarks

Population density is a highly subjective measure depending on the point of view of affected groups. In terms of environmental quality, it is usually associated with carrying capacity, although no specific measures, parameters, or limits seem to exist.

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Account: Social Well-Being

Category: Demographic Characteristics

Variable: Community Growth

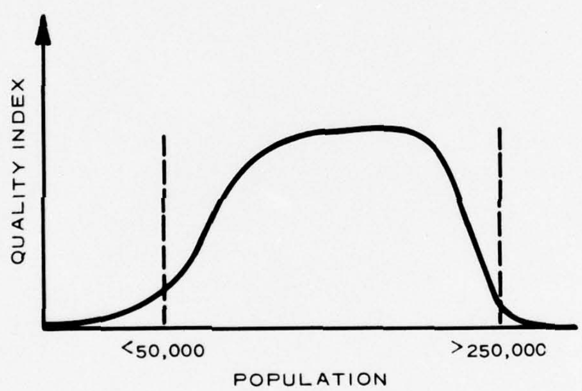
Definition and Measurement

Most often, community growth is defined as the increase in population of a given locality with the attendant increases in community services and facilities.

Functional Curve and Rationale

None available (except an implicit functional relationship for certain schools of thought that the more the growth, the better the community).

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts may be described as those consistent with stated community goals and carrying capacity. However, neither goals nor carrying capacity is usually defined (most of the time they reflect shifting local desires). Adverse impacts can be predicted when communities grow beyond desired levels or when they exceed some notion of carrying capacity.

Remarks

The idealized functional curve assumes that the so-called "good community" involves both a minimum and a maximum size. While the numbers shown reflect some agreement in the literature, they are highly dependent on local circumstances, time, culture, etc. Repeated studies show no conclusive evidence of optimum community size for environmental quality (measured through a variety of social indicators). Sources of information include records of new development, census information, aerial photographs, and local baseline data.

Account: Social Well-Being

Category: Demographic Characteristics

Variable: Population Mobility

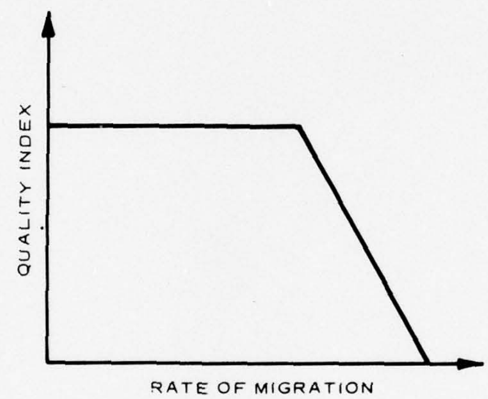
Definition and Measurement

Population mobility can be defined as the ability of individuals to move from one locality to another. This is usually measured as either out-migration or in-migration with the resulting balance expressed as net migration. The percentage of change between selected time periods expresses the rate of migration as part of the overall population change.

Functional Curve and Rational

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Population shifts can be predicted by using trend data for the past and extrapolating into the future. The degree of change due to migration may affect in two different ways social well-being. On the one hand, mobility contributes to the psychological well-being of individuals and economic and social enhancement of a community. On the other hand, significant rates of out-migration create hardships to the community left behind, as well as problems from sudden population influx into host communities. A general observation in the literature is that migration is proportional to the number of opportunities at a given distance.

Remarks

Census and local sources.

Account: Social Well-Being

Category: Community Organization

Variable: Community Cohesion

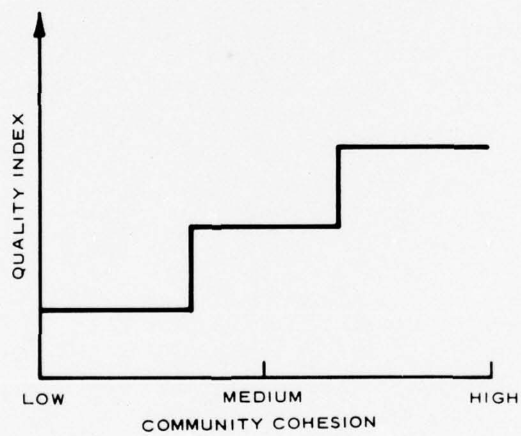
Definition and Measurement

Assuming that one can define community (in either spatial, social, or subjective terms), community cohesion is a composite variable reflecting the degree of attraction of parts, the level of interdependence, and the commonality of social traits providing unifying forces of a group. Cohesiveness describes the sense of community in terms of degree of proximity, interaction, and sharing. There are various measures such as neighborhood index (residential qualities), *social capacity indicators* (perceptions and identification), social interaction analysis (interaction patterns within community boundaries), mobility index (percent of households in the same dwelling unit for 5 yr or more), and a host of social indicators (crime rate, unemployment, subjective group identification).

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Adverse impacts involve the serious disruption of social interaction, transformation in physical proximity, breakdowns in important local institutions, and alterations in behavioral and perceptual relationships (distrust, anxiety about newcomers, suspicion, frustration about the "passing of the good old days"). Alternatively, a project may enhance cohesion by responding to broadly desired community objectives (and in many cases by rallying citizens as opposing forces to projects).

Remarks

This is one of the most celebrated elements of SWB and social impact analysis. Although it is widely discussed, little exists as to its specific dimensions or functional relationships. Information can be obtained indirectly through available data or through surveys for judgment scales. Sources of information also include local mass media analysis and interviews with community leaders.

Account: Social Well-Being

Category: Community Organization

Variable: Displacement of People

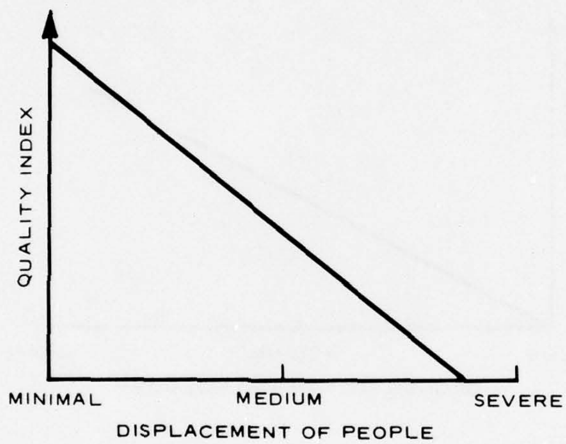
Definition and Measurement

This variable measures the displacement of individuals due to the acquisition of land and associated facilities. Its measurement is based on the actual number of people displaced and on a subjective evaluation of a low to high rate of displacement in the context of the particular community.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Adverse economic impacts occur when individuals or groups suffer losses above and beyond those compensable under law. Furthermore, social dislocations and adverse impacts result from dispersion and from breakdowns in community cohesion (including losses of community institutions). Other predictable impacts involve effects on receiving communities and on individuals who are adapting to a new environment.

Remarks

No agreement exists as to what is minimal or severe displacement. Occasionally displacement may be also advantageous in providing new opportunities for certain groups, e.g., the removal of people from dilapidated areas.

Account: Social Well-Being

Category: Community Organization

Variable: Social Mobility

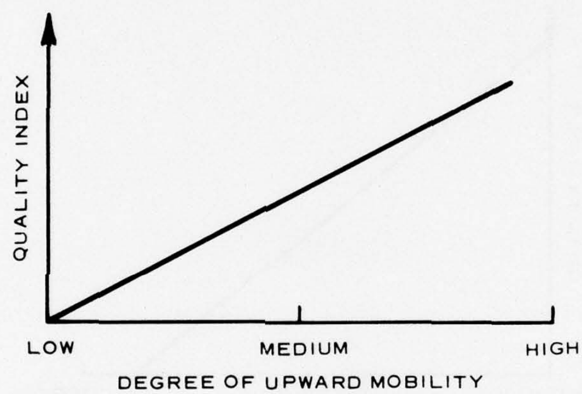
Definition and Measurement

As part of overall community organization, this variable measures the percent of fathers and sons in the same occupational category. It is one of many indexes of occupational shift and attempts to delineate the upward mobility of successive generations.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

The higher the upward mobility, the opportunity for more professional or higher paying jobs, the more the ability to meet basic needs and the higher the satisfaction. Under such conditions positive impacts are to be expected in terms of community solidarity and collective social well-being.

Remarks

Data sources for this variable include employment data described in the census, especially percentage of persons in professional and managerial positions compared with percentage of persons in laboring and service occupations. Longitudinal studies would be particularly useful.

Account: Social Well-Being

Category: Real Income Distribution

Variable: Income Generated

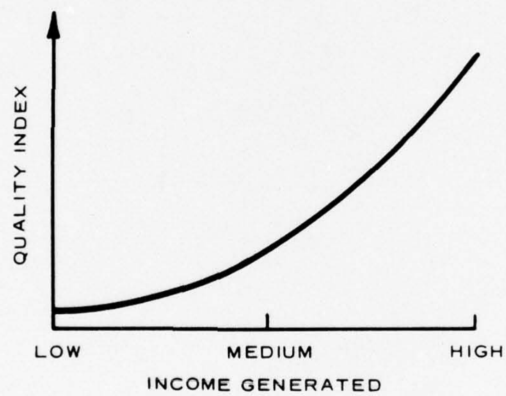
Definition and Measurement

This variable measured by a series of indexes elaborating changes in the level of income attempts to capture monetary benefits to be accrued to various groups by a given project. It is assumed that higher incomes raise both the level of opportunities and the satisfaction accompanying new lifestyles. Measurements usually associated with this variable are median family income and per capita income (family poverty level as defined by the Office of Economic Opportunity may be used as the lowest income group). Subsequent levels of income groups can portray relative cutting points.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

The range of effects involves the number and income class of project beneficiaries; the expected equitable distribution among all groups; and the effect income redistribution will have on expenditures in a community. Usually, income generated is seen as a catalyst for far-reaching changes and secondary impacts in the life of a community (such as income stabilization, better community services, and better standard of living).

Remarks

Composite sources from methodologies examined, especially Bureau of Reclamation (1972). Other sources: census; tax records; and Office of Economic Opportunity.

Account: Social Well-Being

Category: Educational, Cultural, and Recreational Opportunities

Variable: Accessibility

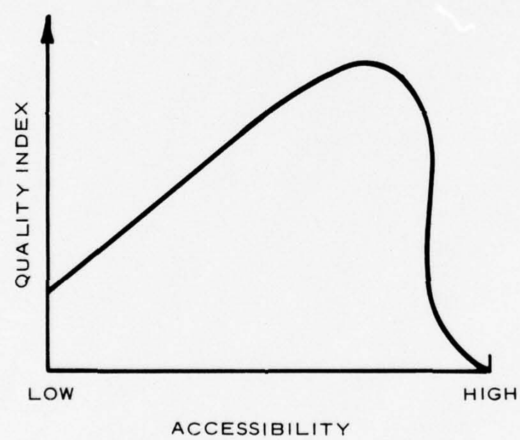
Definition and Measurement

This variable can be broadly defined as the relative ease or difficulty of getting to or from educational, cultural, or recreational opportunities. This variable can be measured by movement patterns relating spatial separation, attractiveness of destination, and costs of movement through such techniques as isochronal maps and comparative graphs showing gains and losses in geographic areas. Rigorous techniques can express in mathematical terms an index of accessibility (which here for reasons of simplicity may range from low to high).

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts refer to increased opportunities for reaching desired destinations. However, adverse (secondary) effects involve potential for sprawl developments, land-use changes, and overuse of recreational activities. The idealized functional relationship assumes a saturation threshold, especially for cases of pristine, relatively isolated environments.

Remarks

This variable should incorporate not only physical accessibility but also perception of accessibility (proxemic configuration). Thus, it is not only physical distance but also the mental map of the perceived attractivity and related distance that comprise a total index of accessibility. Information can be derived from traffic studies as well as from surveys of subjective identification.

Account: Social Well-Being

Category: Educational, Cultural, and Recreational Opportunities

Variable: Recreational Diversity

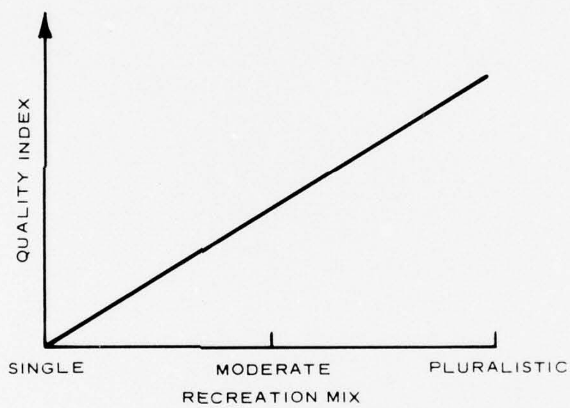
Definition and Measurement

This variable attempts to measure the mix of recreational opportunities. It is based on a subjective measure of single-purpose recreation versus a richer diversity of recreational opportunities. It can be measured by the number of potential activities through consensus subjective scales with arbitrary cutting points at different levels of diversity of envisaged activities. The assumption underlying this variable is that the richer the mix, the higher the satisfaction to diverse groups of citizens.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts may result from more opportunities for recreational participation and from diversified activities. Adverse impacts may also appear from overlapping/competing recreational activities, e.g., fishing versus water skiing.

Remarks

Recreation is difficult to define since it means almost anything people do with their leisure time. Discretionary time use for personal satisfaction and enjoyment can be also used here. Parallel concepts include recreational experience quality as measured through judgments along a relative preference scale.

Account: Social Well-Being

Category: Educational, Cultural, and Recreational Opportunities

Variable: Achievement/Quality

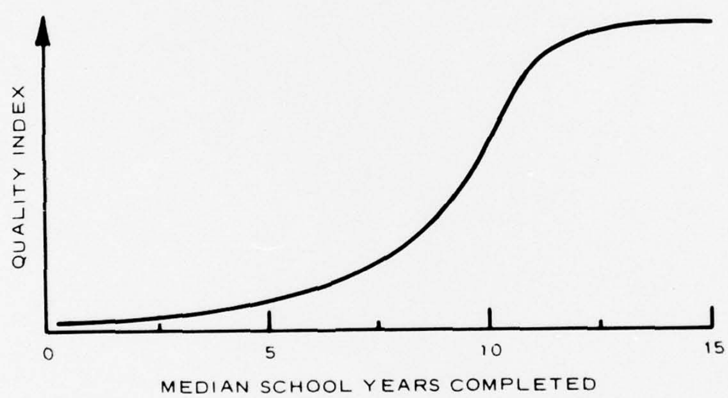
Definition and Measurement

Although parallel indexes may exist to measure a variety of items under achievement or performance, two typical factors describe level of achievement: (a) median school years completed by persons 25 yr and over and (b) percent of persons 25 yr and over who completed 4 yr of high school or more. The first is the basis for the present variable and is based on the assumption that higher education contributes to self-actualization, a higher degree of satisfaction, and therefore more overall fulfillment.

Functional Curve and Rationale

None available.

Idealized Functional Curve and Rationale



Prediction of Impacts

Positive impacts in terms of enhancement and fulfillment occur when individuals have the opportunity through increased education to be employed in higher paying jobs (thus, indirectly also measuring income); to be involved in more meaningful jobs; and to have feelings of self-improvement, goal realization, and personal fulfillment. However, disparities between educational achievement (especially for the highly trained) and actual employment opportunities or individual expectations may cause frustration, dissatisfaction, and other negative impacts.

Remarks

Use standard U. S. census data. Also use state and local information and surveys for measuring attitudes toward satisfaction from achieved educational level.

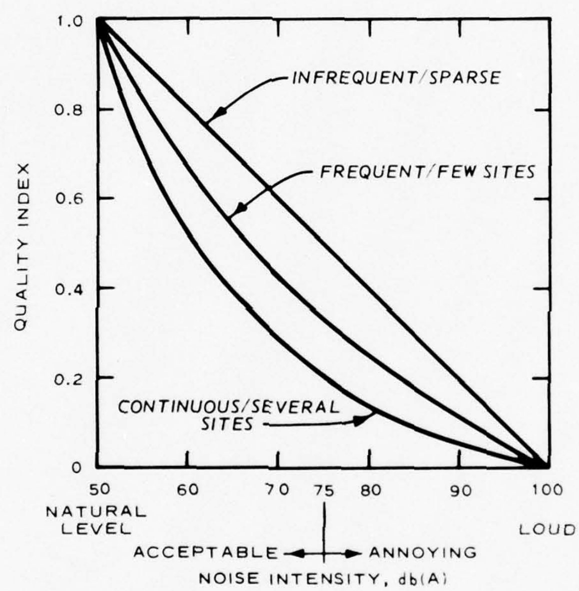
Account: Social Well-Being

Category: Noise

Definition and Measurement

Noise is created both by man's activities and by natural phenomena. Noise may have a physiological effect, in which case it may be considered to be a pollutant, or a psychological effect, in which case it is more of an esthetic factor. For example, the singing of birds and the bubbling of a brook can be considered as desired sounds. In other cases, however, noise can cause damage to man and nature. Some examples of undesirable sounds are noise from the normal operation of project facilities, such as generators and machine shops, or as a result of man's use of water resources projects, such as outboard motors and snowmobiles at recreation areas.

Functional Curve and Rationale



In urban areas where noise is a major problem, several variables of noise are usually of interest, including intensity, frequency distribution, distribution of frequency and intensity throughout the day, variety of sound, and relationship between the sources of noise and the recipients of noise. To avoid the unwarranted complexity of handling these multiple variables, two have been selected for incorporation into a noise value function. These are the intensity of noise and the frequency of occurrence and distribution within the project area. Intensity is represented by conventional decibel db (A) units and by a subjective scale from "natural level" to "loud." Quality index is shown to decrease with both increasing intensity and increasing frequency and distribution.

Prediction of Impacts

See models developed by the U. S. Department of Transportation (1972) and Federal Highway Administration (1973).

Remarks

From Battelle Environmental Evaluation System (Dee et al. 1972).

ACCOUNT	CATEGORY	VARIABLE
RD	INCOME EFFECTS	VALUE OF OUTPUTS
		VALUE TO UNEMPLOYED OR UNDEREMPLOYED RESOURCES
		USER PAYMENTS
		INCREASES FROM INDUCED OR STEMMING ACTIVITIES
		INCREASES FROM CONSTRUCTION AND OPERATION AND MAINTENANCE ACTIVITIES
		LOSSES FROM DISPLACED REGIONAL ACTIVITIES
		LOSSES OF ASSISTANCE AND WELFARE
		INDIRECT INCREASES IN PUBLIC EXPENDITURES
	EMPLOYMENT	LONG-TERM
		SHORT-TERM
	POPULATION DISTRIBUTION	TOTAL POPULATION
		COMPOSITION
	ECONOMIC BASE AND STABILITY	
	ENVIRONMENTAL EFFECTS OF REGIONAL CONCERN	
	REGIONAL EFFECTS ON EDUCATIONAL, CULTURAL, AND RECREATIONAL OPPORTUNITIES	

Figure C4. Structure of the Regional Development account

Account: Regional Development

Category: Income Effects

Variable: Value of Unemployed or Underemployed Resources

Definition and Measurement

Using the full employment assumption stated in Principles and Standards, underemployment or unemployment of resources would occur only during temporary transition periods as resources are moved from lower to higher economic uses. The key criterion in evaluation is the degree of immobility of the resource. Information must be obtained about the individuals and groups in the socioeconomic region under consideration. Then an effort should be made to determine the probable duration of the underemployment or unemployment in the absence of a water resource plan. A two-step approach is recommended: (a) identify all income-generating activities and associated employment under (1) induced and stemming effects and (2) construction and operation and maintenance expenditures and (b) identify those portions of these two categories providing employment to those factors of production not fully or partially utilized. Then adjust the other two estimates to reflect this change.

Functional Curve and Rationale

None available.

Prediction of Impacts

It is expected that underemployed or unemployed resources will be reduced in most cases of plan development, at least for a limited time. The benefits accrued from this variable would then be greatest at the beginning of plan implementation, declining and ending after a period of about 20 yr.

Remarks

The existence of underused or unused resources has to be supported and a demonstration made that they would not be used in the absence of a planned development. Possible references would include publications from the U. S. Department of Commerce, the U. S. Department of Labor, and the U. S. Census Bureau. By comparing local levels of income and employment with national averages and national employment goals, a preliminary basis for separating the underemployed or unemployed category can be derived. From Bureau of Reclamation (1972).

Account: Regional Development

Category: Income Effects

Variable: User Payments

Definition and Measurement

User payments include payments made by the region for resources developed by the plan. These costs are the repayments for project water, power, recreation, fish and wildlife facilities, navigation systems, and/or other project facilities and services for which reimbursement is required.

Functional Curve and Rationale

None available.

Prediction of Impacts

Information on these costs will be generated during Stage 2 of the planning process by the Economics Section.

Remarks

The form of payment may include direct payments for power, irrigation water, municipal and industrial water, local cost-sharing for facility development, or user fees for recreation and fish and wildlife facilities. From Bureau of Reclamation (1972).

Account: Regional Development

Category: Income Effects

Variable: Increases from Construction and Operation and Maintenance Activities

Definition and Measurement

Income impacts will be generated by wages paid to construction workers and from employees involved in operating and maintaining program or project services. Data are available on the number of construction workers, type of work, and salary schedules. Similar data are often developed in estimating annual operation and maintenance expenditures for determining project costs and from actual construction and operation experience. It may also be desirable to derive an income multiplier from existing input-output studies to estimate the total net income generated.

Functional Curve and Rationale

None available.

Prediction of Impacts

Regional expenditures by imported manpower will vary from a high where total disposable wages are spent to a low of subsistence spending.

Remarks

An analysis of the anticipated construction schedule will be necessary to determine construction impacts. From Bureau of Reclamation (1972).

Account: Regional Development

Category: Income Effects

Variable: Losses from Displaced Regional Activities

Definition and Measurement

This variable is the loss of net income in the region from other economic activities as a result of displacement by the plan.

Functional Curve and Rationale

None available.

Prediction of Impacts

Data on this variable will be generated for each alternative plan during Stage 2 of the planning process by the Economics Section.

Remarks

Account: Regional Development

Category: Employment

Definition and Measurement

Beneficial effects are identified and measured as the increase in the number and types of jobs resulting from the project or programs being evaluated. Adverse effects related to regional employment would include any decrease in the number and types of jobs resulting from construction and/or operation of a project or program.

Functional Curve and Rationale

None available.

Prediction of Impacts

Planning reports will provide reasonable estimates of the anticipated increased employment by service, trade, or industrial sector. When possible, the employment increase will be classified with regard to level of skills required.

Remarks

Consideration should be given to the difference between short- versus long-term impacts (construction versus operation and maintainance jobs.) From Bureau of Reclamation (1972).

Account: Regional Development

Category: Population Distribution

Definition and Measurement

Population distribution may be measured by the components of total population, composition, and concentration. Changes (increases, decreases, or stability) may be noted over a period of time for the region to determine trends and make predictions.

Functional Curve and Rationale

None available.

Prediction of Impacts

Beneficial effects will occur when population concentrations of affected planning areas are improved through opportunities created by implementation of a plan. Beneficial effects can be measured as progress toward attainment of specific goals for population dispersal and urban-rural balance is realized. Adverse effects would be plan-induced concentrations of population and employment contrary to specified objectives. Continuing out-migration of regional population could be an adverse effect measured and identified in a future without-plan analysis.

Remarks

From Bureau of Reclamation (1972).

Account: Regional Development

Category: Economic Base and Stability

Definition and Measurement

This category consists of those activities that provide the basic employment and income on which the rest of the regional economy depends. Beneficial effects include contributions to balanced local and regional economies, regularized market activity and employment fluctuations, and reversal in decline of community growth. These beneficial effects will be measured or described by comparative indexes relating to fluctuations in output, employment, and income. Adverse effects would be the result of any plan that would reduce the economic base or result in economic instability contrary to the goals of the region.

Functional Curve and Rationale

None available.

Prediction of Impacts

Impact prediction depends entirely on the existing base and nature of the plan or project being implemented.

Remarks

When the region under study has too great a concentration or specialization in its economic base and the project and program being evaluated would have significant effect in promoting greater diversity, the following information should be shown in planning reports: (a) a statistical description of the area's economic base, highlighting the employment concentrations of concern; (b) projections of future employment both with and without the plan; and (c) the percentage reduction in the area's dependence on its specialized employment base. From Bureau of Reclamation (1972).

Account: Regional Development

Category: Regional Effects on Educational, Cultural, and Recreational Opportunities

Definition and Measurement

Beneficial effects of this component include contributions to (a) improved opportunities for community services (utilities, roads, schools, hospitals, etc.) and (b) more cultural and recreational opportunities (identification of historical sites, new lakes or reservoirs, new recreational facilities. Adverse effects are identified and measured or described as detrimental effects on educational, cultural, or recreational opportunities.

Functional Curve and Rationale

None available.

Prediction of Impacts

A description of improved community services and cultural and recreational opportunities will be provided in planning reports. The numerical increase of services and opportunities will also be provided as appropriate to relate the change in size, use potential, quality, etc., to the with and without analyses.

Remarks

From Bureau of Reclamation (1972).

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APPENDIX D: AN EXAMPLE USE OF WRAM ON A HYPOTHETICAL PROBLEM

1. In order to illustrate the scaling, weighting, and evaluation processes of the Water Resources Assessment Methodology (WRAM), the following hypothetical example is presented. It must be emphasized that this example is presented solely for illustrating the fundamentals of the computational processes. The scope of data presented is not intended to be as extensive as an actual field analysis, but rather is for illustrating WRAM's general applicability given various levels of detail. Similarly the conclusions developed are based on the hypothetical data and analyses presented and do not have general applicability. Although an effort was made to provide a hypothetical example that would be typical of a real-world situation, it should be reemphasized that the primary purpose of the example provided herein is only to show how WRAM can be used.

Description of Hypothetical Study Area

2. The general setting of the study area is illustrated in Figure D1. The study was initiated because of continued flooding from the Any River, which flows out of rugged mountain terrain onto a coastal plain used for the production of commercial timber, cattle, and crops. The stream normally has moderate flows and high water quality; however, during the rainy season flash flooding causes extensive damage to floodplain improvements in nearby Anytown and to outlying agricultural areas.

3. The mountainous upper portion of the drainage basin is forested, relatively undeveloped, and extremely scenic, and has been a favorite retreat for canoeists, stream-fishermen, and naturalists. In several areas, however, poor timber management has resulted in the loss of employment opportunities for residents. The area is currently experiencing a net out-migration of people because of its depressed economy and lack of employment opportunities.

4. Anytown is the only incorporated city in the county. There are several small residential clusters in other areas of the county, but none are in the area of any of the proposed water development alternatives. Anytown has had a fairly stable agricultural base over

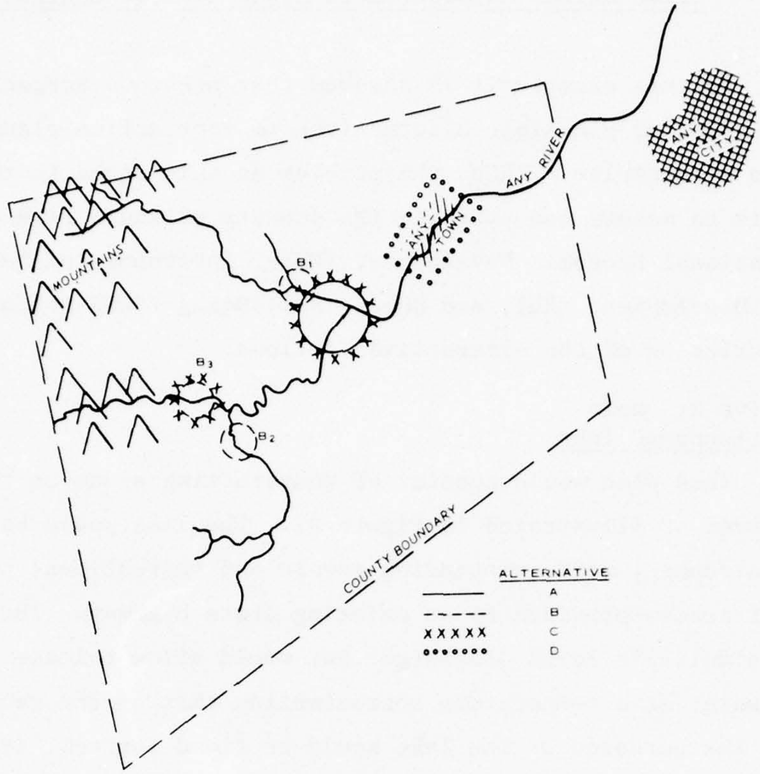

Figure D1. Location map

the years, although this does not provide large numbers of employment opportunities for the young people. The residents of Anytown are basically small-town oriented.

5. In terms of water development plans, the local citizens would welcome relief from their flooding problems. Although there is no need for additional municipal or industrial water supply in the immediate area, a need does exist in the nearby Standard Metropolitan Statistical Area (SMSA), Any City. Additional water for irrigation could be used in the immediate area of Anytown as well as in downstream areas, and there is a need for additional recreational opportunities, especially for the residents of Any City. Although Anytown residents would welcome additional job opportunities, they probably do not want large-scale residential or recreational development, with the accompanying influx of tourists and outsiders.

Alternatives Considered to Achieve Flood Control

6. In this example it is assumed that previous screening has reduced the list of plausible alternatives to four action plans and the no-action alternative. Thus, the problem at this stage in the planning process is to assess and evaluate the impacts of these five alternatives on the National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD), and Social Well-Being (SWB) accounts. A general description of the alternatives follows.

Alternative A: main
stem multipurpose lake

7. This plan would consist of constructing a dam on the main stem of Any River as illustrated in Figure D1. The lake would be deep, clear, and oligotrophic, with outstanding scenic and recreational potential and excellent access provided by an existing state highway. The dam would include a multiple-level discharge that would allow release of high-quality water at a temperature approximating that of the receiving stream. The purposes of the lake would be flood control, irrigation, water supply, and recreation; and the lake would be managed for a warm-water fishery.

Alternative B: three
upstream multipurpose lakes

8. This plan would consist of constructing dams near the mouths of the three major tributaries of Any River. The lakes would serve the same purposes as the main stem lake. The combination of lakes would allow Any River to remain unobstructed but at the expense of providing less flood protection and water supply yield and fewer recreational opportunities because of limited accessibility in the upper reaches. The three dams would not have provisions for multilevel discharge, and the lakes would be more turbid than the main stem lake because of their proximity to logging operations.

Alternative C: dry
lake and upstream storage

9. This plan would consist of an upstream lake to be used for

water supply and irrigation storage and a dam at the site of Alternative A to be operated as a dry lake except during times of flooding. The plan would provide full flood-control benefits without permanent inundation of the main stem but would not provide as many recreational opportunities as Alternatives A or B. This alternative would result in fewer full-time changes to the main stream and tributaries than Alternatives A or B; however, effects on small mammals and low-nesting birds in the dry lake would be severe during flooding.

Alternative D: nonstructural

10. This plan consists of zoning restrictions and the floodproofing of future development beyond that required for minimum compliance with the Flood Disaster Protection Act of 1973 (Public Law 93-234),* assumed for the without project conditions. The plan includes the purchase of vegetative easements and fee purchase of land for river access sites and park development, including urban recreational facilities within Anytown. The plan would preserve much of the existing scenic quality of Any River but would not provide the same degree of flood protection as any of the other alternatives. Irrigation and water supply would not be included as project purposes with this plan, and implementation would be primarily a local responsibility.

Alternative E: no action

11. Under the without project conditions assumed for the no-action alternative, the general flood problem would continue. However, all future development in the floodplain would be in compliance with the minimum standards of the Flood Disaster Protection Act of 1973. Further development of the basin's water resources for irrigation or water supply purposes would not be expected in the foreseeable future. Although the population of the area would be expected to stabilize eventually under the without project conditions, the unfavorable economic climate would prevail. With this alternative, environmental quality in the basin would remain generally high except in the areas of

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* Sources cited in this appendix will be found in the References at the end of the main text.

continued logging activities. Caves inhabited by the Indiana bat and habitats of the bald eagle in the area will not be under any protective jurisdictions and consequently are expected to degenerate in time.

Activities of the Interdisciplinary Team

12. In accordance with WRAM, the members of the interdisciplinary team have been working together since inception of the case study. They have individually and collectively visited the project areas and are familar with local interests, concerns, and attitudes. Team meetings have been opened to allow participation by representatives of citizen groups and local, State, and Federal government agencies. In short, public participation has been continually sought throughout the planning process.

13. Potential problem areas have been identified, and a lengthy list of possible project alternatives has been formulated. Through progressive iterations within the planning stages, the team has narrowed the list to include only the five previously described alternatives. The project is in plan development Stage 3 as described by the Corps ER 1105-2-200 series. The interdisciplinary team has produced a refined list of variables to be considered from a lengthy list of possible ones by calculating relative importance coefficients (RIC's). Baseline data were collected for these selected variables, and the effects of each alternative including the no-action one were predicted to the extent that the state of the art would permit. Where possible, quantitative values were predicted, but for some variables, it was possible only to predict the changes from the base conditions on a qualitative (better or worse) scale.

14. The discussions that follow for each of the four accounts include descriptions of data and the general line of reasoning and computational processes used by the interdisciplinary team in developing RIC's and scale values. The final coefficient matrix tables for each account are presented as a possible technique for displaying adverse and beneficial impacts of each alternative on a relative basis for the

variables within each account. The summations at the bottom of each matrix were provided by the interdisciplinary team to show the relative impacts of the alternatives to each account.

NED Account

15. As described in Principles and Standards, NED is to be achieved "by increasing the value of the nation's output of goods and services and improving national economic efficiency" (Water Resources Council 1973). An estimate of the project net benefits provides a valid measure for evaluating the impact of alternative land and water resource development plans on this objective. Since all components of the NED account are measured in monetary terms, net benefits provide a direct and comparable measure of the impacts of alternatives on the NED objective. It is not necessary to determine or scale the alternatives to determine their impacts or the trade-offs between plans within only the NED account. However, if the methodology is to be used to assist the decisionmaker in evaluating impacts by all accounts, scaling of the NED account (described in the following paragraphs) is required and should be based on the estimates of net benefits.

16. The components and scaling of the NED account for the example are summarized in Table D1. It is assumed in this example that an analysis of the alternatives indicated that no significant external economies or diseconomies would result from their implementation, and these components are therefore not included in the summary.

17. Net benefits are the difference between a plan's beneficial and adverse components. As indicated in Table D1, net benefits for this example range from -$70,000 for Alternative B to $350,000 for Alternative A, and include an estimate of zero for Alternative E, the no-action alternative. As previously discussed, net benefit is the only factor required to evaluate the impacts of the alternatives on the NED objective or to compare trade-offs within the NED account.

18. To scale the alternatives for evaluations between accounts, the values of 1.0 and 0.0 are assigned, respectively, to the alternatives

Table D1

NED Account

Impact	Effect of Alternative	Alternative (Average Annual Equivalents in Thousands of Dollars) A	B	C	D	E
Beneficial	Increased outputs:					
	Flood control	600	500	600	400	--
	Water supply	900	800	800	0	--
	Irrigation	300	300	300	0	--
	Recreation	300	100	10	50	--
	Value of output from unemployed or underemployed resources (Area Redevelopment)	50	80	70	0	--
	Subtotal	2150	1830	1780	450	--
Adverse	Value of resources:					
	Construction	1500	1700	1600	0	0
	Operation and maintenance	300	200	50	410*	0
	Subtotal	1800	1900	1650	410	0
	Net benefits	350	-70	130	40	0
	Scale	1.0	0.0	0.47	0.26	0.16
	Scale value	0.53	0.0	0.25	0.14	0.08

* Includes additional cost of floodproofing future development beyond 100-yr level.

with maximum and minimum net benefits. Values for the remaining alternatives are assigned on the basis of the relative value of their net benefits within this range. For example, the point value for Alternative E is determined by

$$\text{Point value} = \frac{\text{Value of alternative - minimum net benefit}}{\text{Maximum - minimum net benefit}}$$

$$\text{Point value} = \frac{0 - (-70)}{350 - (-70)} = \frac{70}{420} = 0.16$$

Finally the point values are scaled to sum to 1.0 by dividing the individual point values by their sum. Again using Alternative E, the final scale value is determined by

$$\text{Scale value} = \frac{0.16}{1.0 + 0.0 + 0.47 + 0.26 + 0.16} = 0.08$$

EQ Account

19. One of the objectives of Principles and Standards is "to enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems" (Water Resources Council 1973). Principles and Standards states that beneficial and adverse effects of alternative plans on environmental characteristics such as open and green space, wild and scenic rivers, lakes, beaches, and any area of natural beauty; archeological, historical, biological, and geological resources; quality of land, water, and air resources; and irreversible commitments of resources to future use, will be included in the evaluation of the EQ account.

20. This discussion of the EQ account does not emphasize the rationale by which variables were selected for inclusion in the account or the degree of the impacts that have been proposed to be fitted to each of the alternative plans. It is not within the scope of this example to present information on the procedures for determining which

variables should be considered or the extent to which information should be gathered for each variable, i.e. resource allocation. These features of WRAM and the procedures available for refining the impact determination process by successive iterations are discussed in the main text of the report.

21. Baseline and projected environmental conditions for each of the project alternatives are summarized in Table D2. A table of factors for converting metric (SI) units of measurement to U. S. customary units and U. S. customary units to metric (SI) units is given on page 7. As would be the case in any environmental assessment, it is not possible to quantify all variables; however, qualitative descriptors (beneficial to adverse) of impacts can be effectively used if quantitative data cannot be obtained for specific variables.

RIC

22. Within the EQ account, three levels of specificity of variables were considered (Table D3). The variables within each level were ranked using the pairwise comparison technique, including a dummy variable to ensure that all variables would have a RIC greater than zero. For example, at the first level, it was felt by the interdisciplinary team that terrestrial and aquatic variables were of equal importance and that air variables were not as important to the region in this example problem. The resulting calculation of the RIC for this level is shown in the following tabulation.

Variable	Assignment of Values						Sum	RIC
Terrestrial	0.5	1	1				2.5	0.42
Aquatic	0.5			1	1		2.5	0.42
Air		0		0		1	1.0	0.16
Dummy			0		0	0	0.0	0.00
				Total			6.0	1.00

Note: The RIC values displayed here are strictly for illustration. They were calculated for use in this example problem by the interdisciplinary team.

Table D2

Baseline and Predicted Quality of Selected Environmental Variables

Variable	Baseline	Alternative				
		A	B	C	D	E (No Action)
Terrestrial						
Cropland, number of acres						
Corn	20,000	19,100	19,950	18,950	20,000	20,000
Wheat	5,000	4,550	4,925	4,475	5,000	5,000
Alfalfa	5,000	4,850	4,925	4,925	5,000	5,000
Pasture, acres	30,000	10,950	25,650	13,050	28,000	28,000
Timberland, acres	80,000	74,000	60,600	68,000	75,000	70,000
Species richness						
Trees	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Shrubs	High	Low	Moderate	Moderate	High	Low
Successional stage	Intermediately stable	Intermediately stable	Intermediately stable	Intermediately stable	Intermediately stable	Intermediately stable
Relative diversity of small mammals	Moderate	High	High	Moderate	High	Moderate
Number of mammals expected	50	High	Moderate	Moderate-high	High	High
Aquatic						
Total stream length, km	381	344	330	350	381	381
Avg stream width, m	135	200	150	140	135	135
Stream impounded, km per recreation pool	0	48	32	17	0.00	0.00

(Continued)

Table D2 (Concluded)

Variable	Baseline	Alternative				
		A	B	C	D	E (No Action)
Aquatic (Continued)						
Straight-line stream length, km	20	206	206	206	206	206
Surface water area, sq km	36	82	59	40	36	36
pH	7.3	7.8	7.5	7.6	7.2	7.2
DO, mg/ℓ	6.9	6.3	6.5	6.3	5.8	5.8
Turbidity, JTU	70	0-20	80	90	110	120
Benthic, $\overline{d}$	3.04	2.0	2.1	2.3	2.75	2.75
Fish, $\overline{d}$	3.61	2.4	2.4	2.1	3.00	3.00
Aquatic vegetation production	Low	Highest	Intermediate	Intermediate	Intermediate	Intermediate
Endangered fish	2	Bad	Worst	Moderate	Moderate	Moderate
Bacteriological concentration	No problem	No problem	No problem	No problem	No problem	No problem
Water flow	Moderate	Stabilized	Stabilized	Moderately stable	Seasonly dry	Seasonly dry
Air						
Gases, tons/year	4000	4200	4100	4000	4000	4000
Dusts, tons/year	1000	1400	1200	1100	1000	1000
Noise, db	50	55	52	52	60	50

Table D3

EQ Account

Variable	RIC - Level 1	RIC - Level 2	RIC - Level 3	Final RIC	ACC - Alternative A	ACC - Alternative B	ACC - Alternative C	ACC - Alternative D	ACC - Alternative E	Final Coefficient Matrix - Alternative A	Final Coefficient Matrix - Alternative B	Final Coefficient Matrix - Alternative C	Final Coefficient Matrix - Alternative D	Final Coefficient Matrix - Alternative E
Terrestial	0.417													
Cropland		0.054												
Corn			0.500	0.0113	0.10	0.20	0.00	0.35	0.35	0.0012	0.0022	0.0000	0.0039	0.0039
Wheat			0.250	0.0056	0.10	0.20	0.00	0.35	0.35	0.0006	0.0011	0.0000	0.0020	0.0020
Alfalfa			0.250	0.0056	0.30	0.10	0.00	0.30	0.30	0.0017	0.0006	0.0000	0.0017	0.0017
Pasture		0.089		0.0371	0.00	0.20	0.10	0.35	0.35	0.0000	0.0074	0.0037	0.0130	0.0130
Timberland		0.125		0.0521	0.30	0.00	0.10	0.40	0.20	0.0156	0.0000	0.0052	0.0208	0.0104
Species richness		0.178												
Trees			0.500	0.0371	0.20	0.20	0.20	0.20	0.20	0.0074	0.0074	0.0074	0.0074	0.0074
Shrubs			0.500	0.0371	0.05	0.30	0.20	0.40	0.05	0.0019	0.0111	0.0074	0.0148	0.0019
Successional stage		0.178		0.0742	0.20	0.20	0.20	0.20	0.20	0.0148	0.0148	0.0148	0.0148	0.0148
Mammals (diversity)		0.178		0.0742	0.30	0.30	0.05	0.30	0.05	0.0023	0.0223	0.0037	0.0223	0.0037
Endangered species (2 species)		0.196		0.0817	0.10	0.35	0.35	0.10	0.10	0.0082	0.0286	0.0286	0.0082	0.0082
								Subtotal		0.0537	0.0955	0.0708	0.1089	0.0670
Aquatic	0.417													
Sinuosity		0.028		0.0117	0.19	0.17	0.20	0.22	0.22	0.0022	0.0020	0.0023	0.0026	0.0026
Surface area		0.083		0.0346	0.33	0.23	0.16	0.14	0.14	0.0114	0.0080	0.0055	0.0048	0.0048
Physicochemical		0.167												
pH			0.167	0.0116	0.20	0.20	0.20	0.20	0.20	0.0023	0.0023	0.0023	0.0023	0.0023
DO			0.417	0.0290	0.20	0.20	0.20	0.20	0.20	0.0058	0.0058	0.0058	0.0058	0.0058
Turbidity			0.417	0.0290	0.54	0.18	0.14	0.08	0.06	0.0157	0.0052	0.0041	0.0023	0.0017
Benthic diversity		0.153		0.0638	0.18	0.18	0.21	0.22	0.22	0.0115	0.0115	0.0134	0.0140	0.0140
Fish diversity		0.153		0.0638	0.19	0.19	0.16	0.23	0.23	0.0121	0.0121	0.0102	0.0147	0.0147
Aquatic vegetation (cover)		0.125		0.0521	0.25	0.25	0.25	0.25	0.25	0.0000	0.0130	0.0130	0.0130	0.0130
Water flow (stabilized)		0.139		0.0580	0.25	0.25	0.40	0.05	0.05	0.0145	0.0145	0.0230	0.0029	0.0029
Endangered fish (2 species)		0.153		0.0638	0.05	0.05	0.30	0.30	0.30	0.0032	0.0032	0.0191	0.0191	0.0191
								Subtotal		0.0787	0.0776	0.0987	0.0815	0.0809
Air	0.167													
Gas		0.167		0.0279	0.06	0.13	0.27	0.27	0.27	0.0017	0.0036	0.0075	0.0075	0.0075
Dusts		0.417		0.0696	0.07	0.13	0.20	0.30	0.30	0.0049	0.0090	0.0139	0.0208	0.0208
Noise		0.417		0.0696	0.00	0.10	0.25	0.25	0.40	0.0090	0.0160	0.0160	0.0056	0.0230
								Subtotal		0.0156	0.0286	0.0374	0.0339	0.0513
			Total	1.0005						0.1480	0.2017	0.2069	0.2243	0.1992

23. RIC's were calculated for levels 2 and 3 in the same manner. For example, each set of terrestrial variables in level 2 associated with a particular variable in level 1 were ranked against each other as were all variables in level 3 that were associated with the same variable in level 2. All calculated RIC's are displayed in Table D3, as are the products of RIC's obtained by multiplying the RIC for each variable in level 3 by the RIC's of the associated variables in levels 2 and 1. For those variables that are not subdivided below level 2, the RIC product was obtained by multiplying the RIC of the variable in level 2 by the RIC of the associated variable in level 1. It should be noted that as a check, the product RIC's will sum to unity at each level.

Red-flagged variables

24. In the EQ account, two endangered species of terrestrial animals and two endangered fish species were considered to warrant additional consideration. In this example the red flagging was used solely to draw attention to these species during the RIC calculations. In different situations, red-flagged variables may warrant more importance than was determined for this example problem.

Alternative Choice Coefficient (ACC)

25. ACC's are numerical values calculated to show the relative effects of the alternatives on a specific variable. A dummy alternative is not used in the calculation of ACC's. To illustrate the various types of data that can be used in calculating ACC's, the following examples are given.

26. Use of qualitative data. Table D2 illustrates the use of qualitative data regarding the prediction of impacts of the various alternatives on species diversity of small mammals. The data in Table D2 indicate that diversity of small mammals is presently moderate and would remain moderate with implementation of Alternatives C and E. Alternatives A, B, and D would enhance diversity. The following ACC's were derived using pairwise comparison with the supposition that a greater diversity of mammals is better because of the stability gained.

Alternative	Assignment of Values										Sum	ACC
A	0.5	1	0.5	1							3	0.30
B	0.5				1	0.5	1				3	0.30
C		0			0			0	0.5		0.5	0.05
D			0.5			0.5		1		1	3	0.30
E				0			0		0.5	0	0.5	0.05
										Total	10.0	1.00

27. Use of quantitative data. Quantitative impacts can be scaled in at least three different ways: (a) quality index values can be determined directly from an existing appropriate functional relationship curve; (b) values can be treated as qualitative (best to worst) and compared by the pairwise comparison technique; or (c) the values can be proportioned by the linear scaling technique.

28. Sinuousity, a measure of the actual stream length between two points divided by the straight-line distance between those points, can be shown to illustrate the first case. The U. S. Army Engineer Division, Lower Mississippi Valley (LMVD), has developed a functional relationship curve that was considered appropriate and was used for this variable (LMVD 1976). In general this curve depicts a higher quality index value for greater sinuosity (Figure D2).

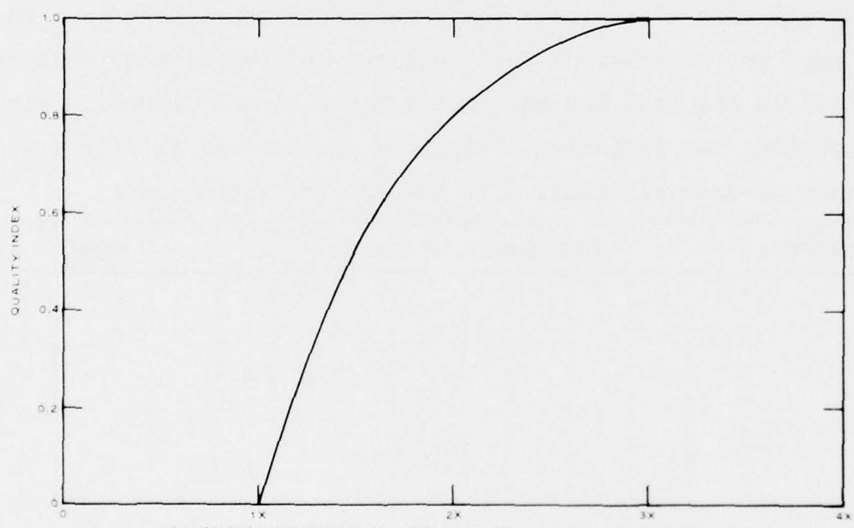

Figure D2. Functional relationship curve (from LMVD 1976)

29. Values for total stream length and straight-line length were obtained from Table D2 and scaled from the LMVD curve to obtain the following values for the alternatives:

Alternative	Sinuosity	Quality Index	Proportioning	ACC
A	1.67	0.65	0.65/3.44	0.19
B	1.60	0.61	0.61/3.44	0.17
C	1.70	0.68	0.68/3.44	0.20
D	1.85	0.75	0.75/3.44	0.22
E	1.85	0.75	0.75/3.44	0.22
	Total	3.44		1.00

As can be seen from this example, it was deemed necessary to modify the quality index values taken from a functional relationship curve to force the quality index values for each alternative to sum to unity.

30. In situations for which there are quantitative data but no useful functional relationship curve, the interdisciplinary team can either develop the functional curves if ample information is available or make qualitative comparisons using the weighted rankings technique. The hypothetical data in Table D2 for amount of timberland can be used to demonstrate this situation. The interdisciplinary team made the decision that for a number of environmental considerations, timberland is essential to the area and any losses would be detrimental. With this assumption, the following tabulation was derived to illustrate the contribution of each alternative to the ACC for timberland:

Alternative	Assignment of Values										Sum	ACC
A	1	1	0	1							3.0	0.30
B	0				0	0	0				0.0	0.00
C		0			1			0	0		1.0	0.10
D			1			1		1		1	4.0	0.40
E				0			1	1	1	0	2.0	0.20
							Total				10.0	1.00

31. An example of the third way in which quantitative data can

be used is provided by the data in Table D2 presented for the aquatic variable, water surface area. Because increased surface area would increase the amount of solar energy striking the aquatic environment on a surface area basis, which would in turn enhance productivity, the interdisciplinary team decided that increased aquatic surface area would be beneficial to the environment. It was arbitrarily decided to proportion the values by dividing the surface areas that would result from implementing an alternative by the total obtained by adding all surface acres. This manipulation results in ACC values that sum to unity as indicated in the following:

Alternative	Surface Area sq km	Proportioning	ACC
A	81.88	81.88/252.68	0.33
B	58.89	58.89/252.68	0.23
C	40.07	40.07/252.68	0.16
D	35.92	35.92/252.68	0.14
E	35.92	35.92/252.68	0.14
Total	252.68		1.00

32. ACC values were determined for each variable in the EQ account by one of the methods discussed previously and are displayed in Table D3. The final coefficients (scores) for each variable were derived by multiplying the RIC product by the ACC for each alternative. Assuming that the differences between the sums for each alternative are significant, implementation of Alternative D would be most beneficial for the terrestrial and aquatic categories, and implementation of Alternative E (no action) would be most favorable for air resources of the study area. It can be seen, however, that because of the greater weights that were given to the terrestrial and aquatic categories by the interdisciplinary team through the assignment of RIC's, Alternative D has the greatest potential in terms of enhancing environmental quality. It can also be seen that only Alternative A, if implemented, would lead to a situation that would be worse than that of the no-action alternative.

RD Account

33. In accordance with Principles and Standards, the beneficial or adverse effects of proposed plans are to be considered "on a system of relevant regions (States, river basins, or communities)" and "will be displayed where appropriate" (Water Resources Council 1973). For this example two regions have been delineated: Region I, the county within which the sites of the action plans and Anytown are located, and Region II, the remainder of the state within which this county is located.

34. The RD account includes both monetary (income) and nonmonetary impacts. Whenever possible, the income variables should be measured in their absolute dollar terms. Scaling of the regional income impacts between alternatives can then be accomplished in the same manner as the scaling of the NED account by (a) summing all variables measured in absolute dollars; (b) assigning a point value of 1.0 to the alternative with the highest net regional benefit and a point value of 0.0 to the alternative with the lowest net regional benefits; (c) interpolating point values between 1.0 and 0.0 for the remaining alternatives; and (d) scaling the point values so that they sum to 1.0.

35. In many actual planning situations, insufficient information is available to determine the absolute dollar impacts of all income variables. When data are insufficient, variables with comparable monetary measures can still be summed for scaling, while qualitative judgment, pairwise comparison techniques, functional curves, or some other appropriate technique will be needed for scaling the remaining variables. To ensure that all variables receive appropriate consideration in the evaluation process, an RIC is assigned to each variable, including all with comparable monetary values. The RIC's of these comparable variables are summed to determine the appropriate weight of their combined ACC's in deriving the final coefficient matrix.

36. The measurements used for determining the ACC's for the income variables for Region I in the example are summarized in Table D4. Three techniques for measuring relative differences in impacts between

Table D4

RD Account: Region I Income Effects

Measurement Technique	Variable	Alternative-Income Effects in Thousands of Dollars				
		A	B	C	D	E
Direct	Value of outputs					
	Flood control	600	550	600	400	0
	Irrigation	150	150	150	0	0
	Recreation	100	50	10	50	0
	Value to unemployed or underemployed resources	150	147	87	0	0
	User payments	-200	-170	-400	-410	0
	Net regional effects	800	727	447	40	0
Indirect	Increases from induced or stemming activities	200	50	0	0	0
	Losses of assistance and welfare	150	147	87	87	0
Qualitative judgment	Increases from construction and operation and maintenance activities	High	High	High	Low	Low
	Losses from displaced regional activities	High	High	High	Low	Low
	Indirect increases in public facility or service expenditures	High	High	Moderate	Low	Low

alternatives are illustrated: direct, indirect, and qualitative judgment.

37. It was assumed for this example that the value of outputs, the value to unemployed or underemployed resources, and user payments can be directly measured for Region I in absolute dollar terms. These measures can then be summed to determine their net regional impact with appropriate ACC's determined by the use of the linear scaling process described previously.

38. In some planning situations, insufficient information is available to enable direct variable measurement, but sufficient information is available to provide an indirect measure that will provide a more accurate estimate of relative differences between the impacts of alternatives than qualitative judgment. Two examples are presented in Table D4. Recreation benefits attributable to visitors originating from outside Region I were used as an indirect measure for increases from induced and stemming activities, and the value to unemployed or underemployed resources was used for loss of assistance and welfare. Again the linear scaling technique described previously is used to derive ACC's for these variables from the indirect measures.

39. It should be noted in Table D4 that the value to unemployed or underemployed resources for Alternative D is estimated to be 0.0 when used as a direct income measure, but $87,000 when used as an indirect measure of losses of assistance and welfare. This inconsistency is appropriate. Alternative D was assumed to be primarily a local responsibility. Any payments to unemployed or underemployed resources in Region I from the implementation of Alternative D would be intraregional transfers that would not result in any net income gains for Region I. However, the income redistribution effect of such transfers would result in the loss of Federal and State monies for assistance and welfare programs within this region.

40. When insufficient information is available to determine either direct or indirect measures of the impacts, the interdisciplinary team will have to use qualitative judgment. Examples in Table D4 include increases from construction and operation and maintenance

activities (greatest impact from wages to out-of-area workers during construction activities for Alternatives A, B, and C), losses from displaced regional activities (Alternatives A and B would displace some gravel operations), and indirect increases in public facility or service expenditures (Alternatives A and B are expected to result in the greatest need for services for out-of-area construction workers and recreation visitors, Alternative C less, and Alternatives D and E the least). ACC's for these variables are then derived by the pairwise comparison technique. An example for losses from displaced regional activities is presented in the following tabulation. As illustrated in this example, Alternatives A and B are expected to result in the greatest displacement of regional activities and are, therefore, the least desirable.

Alternative	Assignment of Values										Sum	ACC
A	0.5	0	0	0							0.5	0.05
B	0.5				0	0	0				0.5	0.05
C		1			1			0.5	0.5		3.0	0.30
D			1			1		0.5		0.5	3.0	0.30
E				1			1		0.5	0.5	3.0	0.30
								Total			10.0	1.00

41. Other income variables considered by the interdisciplinary team in the RD analysis for Region I included external economies and diseconomies and regional contributions not included in direct user payments. The impact of the alternatives on these variables was determined to be insignificant, and they were considered by the interdisciplinary team to be of insufficient importance to be included in the final evaluation.

42. Similar analyses as described previously were used by the interdisciplinary team to measure and scale the impacts of the alternatives for the remaining variables within the RD account for Regions I and II. The ACC's derived from these analyses are presented in Table D5. Also presented in Table D5 are the RIC's derived by the interdisciplinary team and the final coefficient matrix for the RD account. The rationale and derivation of the RIC's for the first level of variables within Region I are discussed as follows.

Table D5

RD Account

Variable	RIC - Level 1	2	3	4	Final RIC	ACC - Alternative A	B	C	D	E	Final Coefficient Matrix - Alternative A	B	C	D	E
Region I	0.67														
Income effects		0.21													
Value of outputs			0.20												
Value to unemployed or under-employed resources			0.10		0.0704	0.40	0.36	0.22	0.02	0.00	0.0282	0.0253	0.0155	0.0014	0.0000
User payments			0.20												
Increases from induced or stemming activities			0.10		0.0141	0.80	0.20	0.00	0.00	0.00	0.0113	0.0028	0.0000	0.0000	0.0000
Increases from construction and operation and maintenance activities			0.10		0.0141	0.30	0.30	0.30	0.05	0.05	0.0042	0.0042	0.0042	0.0007	0.0007
Losses from displaced regional activities			0.10		0.0141	0.05	0.05	0.30	0.30	0.30	0.0007	0.0007	0.0042	0.0042	0.0042
Losses of assistance and welfare			0.10		0.0141	0.00	0.00	0.27	0.27	0.46	0.0000	0.0000	0.0038	0.0038	0.0065
Indirect increases in public expenditures			0.10		0.0141	0.05	0.05	0.20	0.35	0.35	0.0007	0.0007	0.0028	0.0049	0.0049
Employment		0.21													
Long term			0.67												
Direct				0.50	0.0471	0.36	0.23	0.07	0.34	0.00	0.0170	0.0108	0.0033	0.0160	0.0000
Indirect				0.50	0.0471	0.40	0.30	0.10	0.10	0.10	0.0188	0.0141	0.0047	0.0047	0.0047
Short term			0.33												
Direct				0.50	0.0232	0.25	0.40	0.35	0.00	0.00	0.0058	0.0093	0.0081	0.0000	0.0000
Indirect				0.50	0.0232	0.20	0.40	0.30	0.05	0.05	0.0046	0.0093	0.0070	0.0012	0.0012
Population distribution		0.14													
Total population			0.67		0.0628	0.00	0.10	0.25	0.25	0.40	0.0000	0.0063	0.0157	0.0157	0.0251
Composition			0.33		0.0310	0.25	0.25	0.25	0.25	0.00	0.0078	0.0078	0.0078	0.0078	0.0000
Economic base and stability		0.29			0.1943	0.40	0.30	0.20	0.05	0.05	0.0777	0.0583	0.0389	0.0097	0.0097
Environmental effects of regional concern		0.10			0.0670	0.17	0.20	0.21	0.22	0.20	0.0114	0.0134	0.0141	0.0141	0.0134
Regional effects on education, cultural and recreational opportunities		0.05			0.0335	0.20	0.05	0.05	0.35	0.35	0.0067	0.0017	0.0017	0.0017	0.0117
Region II	0.33				0.3300	0.24	0.22	0.19	0.20	0.15	0.0792	0.0726	0.0627	0.0660	0.0495
				Total	1.0001						0.2741	0.2373	0.1945	0.1519	0.1316

Variable	Assignment of Values																					Sum	RIC
Income effects	0.5	1	0	1	1	1																4.5	0.21
Employment	0.5						1	0	1	1	1											4.5	0.21
Population distribution		0					0					0	1	1	1							3.0	0.14
Economic base and stability			1					1				1				1	1	1				6.0	0.29
Environmental effects of regional concern				0					0				0			0			1	1		2.0	0.10
Regional effects, on education, culture, and recreation opportunities					0					0				0			0		0		1	1.0	0.05
Dummy						0					0				0			0		0	0	0.0	0.00
Total																						21.0	1.00

Note: It must be emphasized that the RIC values described herein are solely for illustration. They were developed by one interdisciplinary team for the hypothetical setting of Region I and should not be considered as having any general applicability.

43. As illustrated in the preceding tabulation, the economic base and stability variable was rated as most important by the interdisciplinary team for Region I. This rating is justified for this example because of the poor and declining economic conditions described for Anytown and the surrounding area. Without an improvement in the economic conditions, little else may be accomplished. It is also reasonable then that the related economic variables of income and employment are also considered more important than the other factors. Environmental quality and cultural opportunities are not considered as important by the residents of the area given their present economic plight.

44. In order to derive the final coefficient matrix presented in Table D5, a final RIC value must be derived for each variable for which ACC's have been determined. This final RIC value is derived by multiplying the individual RIC's for each level from which a given variable was disaggregated. For example, the final RIC for losses of assistance and welfare in Region I (0.0141) was derived by multiplying the RIC for Region I (0.67) by the RIC for income effects (0.21) and this product (0.14) by the RIC for losses of assistance and welfare (0.10).

The final coefficient matrix is the product of the ACC's and the appropriate final RIC.

45. Alternatives for the RD account are ranked by summing the columns of the final coefficient matrix. In this example, Alternative A, with a total of 0.2741, is the best alternative when considering regional development while Alternative E, with a total of 0.1316, is the worst.

SWB Account

46. Water and land resource plans, if implemented, may result in significant effects on social well-being. As stated in Principles and Standards, "these effects reflect a highly complex set of relationships and interactions between inputs and outputs of a plan and the social and cultural setting in which these are received and acted upon" (Water Resources Council 1973). It is beyond the scope of this example to go into specific measurements for social impact assessment. Once the processes of impact assessment are completed, however, the variables and impacts may be listed and weighted for the alternatives under consideration.

47. Table D6 presents examples of variable measurements considered in this problem. As previously described in the RD account, the scaling of the impacts may be based not only on quantitative data but also on the interdisciplinary team's professional judgments. For some of the input variables of the SWB account, either direct or indirect quantitative measures exist; for others, however, only qualitative ratings of impacts, such as high-moderate-low, are possible.

48. The variables entitled "direct tax increases" and "flood damages prevented" in Table D6 provide examples of quantitative measures that can be used for scaling within the SWB account. Estimates of the local share of the costs of implementation of the various alternatives provide the variable measurements for the former; estimates of expected flood damages prevented, for the latter. The process of linear scaling of the differences between alternatives for direct tax increase (flood

Table D6

Examples of SWB Variables

Variable	Alternative				
	A	B	C	D	E
Income generated, median family income, dollars	10,875	10,250	9,500	8,550	8,500
Direct tax increase, dollars	200,000	170,000	400,000	410,000	0
Flood damage prevented, dollars	600,000	550,000	600,000	400,000	0
Morbidity	Moderate	Moderate	Moderate	Low	High
Accessibility	High	Moderate	High	Moderate	High
Public facilities and services	Low	Low	Moderate	High	High
Variety of recreational activities	High	Moderate	Low	Moderate	Moderate
Esthetic satisfaction	Low	Low	Low	High	High
Population projection, 10 yr	15,272	13,255	12,292	11,985	9,126
Community cohesion unemployment rate, percent	6	7	7	10	9
Mobility, net migration, percent	52	32	22	19	-8
Displacement of individuals	101	80	55	50	0

damages prevented) is as follows: (a) assign a value of 1.0 to Alternative E (Alternatives A and D) and a value of 0.0 to Alternative D (Alternative E); (b) interpolate point values between 1.0 and 0.0 based on the variable measurements; and (c) scale the point values to sum to 1.0.

49. Several examples of more subjectively determined impacts are also presented. It is in these cases that the values of the community come into force, and quantitative measures are not sufficient or available. The effects of the proposed alternatives on public facilities and services are judged in view of the community's highly valued stability and inability to support large influxes of new residents. These factors also come into play in determining the impacts on the index of esthetic satisfaction. The people of Anytown value their present social and physical environment; the alternatives that would cause the greatest change are, therefore, the least desirable. Another subjectively determined measure is the variety of recreational activities. Although the residents currently enjoy a varied mix of recreational activities and do not want rapid growth or development in the area, they would enjoy and appreciate improvements in the types of activities available to them. In this instance, therefore, the large-reservoir alternative is most desirable. In each of these subjectively ranked measures, the pairwise comparison is used to derive the ACC's, as illustrated for public facilities and services in the following tabulation.

Alternative	Assignment of Values										Sum	ACC
A	0	0	0	0							0.0	0.00
B	1				0	0	0				1.0	0.10
C		1			1			0	0		2.0	0.20
D			1			1		1		0.5	3.5	0.35
E				1			1		1	0.5	3.5	0.35
										Total	10.0	1.00

50. ACC's for the SWB account are presented in Table D7. Data for several additional variables were gathered and examined, but were not included in the final analysis because of their lack of relevance to the choice of alternatives. In other instances, data for more than

Table D7

SWB Account

Variable	RIC - Level				Final RIC	ACC - Alternative					Final Coefficient Matrix - Alternative				
	1	2	3	4		A	B	C	D	E	A	B	C	D	E
Real income distribution	0.14														
Income generated		0.50			0.0700	0.40	0.30	0.20	0.05	0.05	0.0280	0.0210	0.0140	0.0035	0.0035
Contributions		0.50													
Expected increases in taxes			0.50												
Direct				0.50	0.0175	0.20	0.30	0.05	0.05	0.40	0.0035	0.0052	0.0008	0.0008	0.0070
Indirect				0.50	0.0175	0.05	0.10	0.15	0.35	0.35	0.0008	0.0017	0.0026	0.0061	0.0061
Revenue generated			0.50		0.0350	0.40	0.25	0.25	0.10	0.00	0.0140	0.0087	0.0087	0.0035	0.0000
Life, health and safety	0.24														
Risk		0.50													
Damages			0.67		0.0804	0.30	0.25	0.30	0.15	0.00	0.0241	0.0201	0.0241	0.0120	0.0000
Accidents			0.33		0.0396	0.00	0.10	0.30	0.40	0.20	0.0000	0.0039	0.0118	0.0158	0.0079
Pathogens		0.33			0.0792	0.10	0.00	0.20	0.35	0.35	0.0079	0.0000	0.0158	0.0277	0.0277
Noxious effects		0.17													
Noise			0.25		0.0102	0.00	0.10	0.20	0.35	0.35	0.0000	0.0010	0.0020	0.0035	0.0035
Hazards			0.75		0.0306	0.20	0.20	0.20	0.40	0.00	0.0061	0.0061	0.0061	0.0122	0.0000
Educational, cultural and recreational opportunities	0.09														
Amenities		0.50													
Accessibility/transportation			0.50		0.0225	0.20	0.00	0.10	0.35	0.35	0.0045	0.0000	0.0022	0.0078	0.0078
Public services and facilities			0.50		0.0225	0.00	0.10	0.20	0.35	0.35	0.0000	0.0022	0.0045	0.0078	0.0078
Opportunities		0.50													
Recreation (total)			0.10		0.0045	0.40	0.30	0.00	0.10	0.20	0.0018	0.0013	0.0000	0.0004	0.0009
Recreation (variety)			0.30		0.0135	0.40	0.20	0.00	0.20	0.20	0.0054	0.0027	0.0000	0.0027	0.0027
Esthetic satisfaction			0.30		0.0135	0.00	0.15	0.15	0.35	0.35	0.0000	0.0020	0.0020	0.0047	0.0047
Life style			0.30		0.0135	0.10	0.10	0.10	0.35	0.35	0.0013	0.0013	0.0013	0.0047	0.0047
Emergency preparedness	0.12														
Resources		0.67			0.0804	0.30	0.30	0.30	0.05	0.05	0.0241	0.0241	0.0241	0.0040	0.0040
Spatial distributions		0.33			0.0376	0.00	0.40	0.30	0.15	0.15	0.0000	0.0158	0.0118	0.0059	0.0059

(Continued)

Table D7 (Concluded)

Variable	RIC - Level				Final RIC	ACC - Alternative					Final Coefficient Matrix - Alternative				
	1	2	3	4		A	B	C	D	E	A	B	C	D	E
Demographic characteristics	0.24														
Population		0.50													
Number			0.50		0.0600	0.00	0.10	0.25	0.25	0.40	0.0000	0.0060	0.0150	0.0150	0.0240
Composite			0.50												
Dependency				0.50	0.0300	0.25	0.25	0.25	0.25	0.00	0.0075	0.0075	0.0075	0.0075	0.0000
Homogeneity				0.50	0.0300	0.05	0.05	0.30	0.30	0.30	0.0015	0.0015	0.0090	0.0090	0.0090
Vital rates (migration)		0.50			0.1200	0.05	0.20	0.30	0.40	0.05	0.0060	0.0240	0.0360	0.0480	0.0060
Community organization	0.17														
Cohesion		0.16													
Unemployment			0.40		0.0108	0.40	0.25	0.25	0.05	0.05	0.0043	0.0027	0.0027	0.0005	0.0005
Identification			0.15		0.0040	0.05	0.10	0.20	0.30	0.35	0.0002	0.0004	0.0008	0.0012	0.0014
Crime			0.15		0.0040	0.05	0.05	0.30	0.30	0.30	0.0002	0.0002	0.0012	0.0012	0.0012
Mobility			0.30		0.0081	0.15	0.15	0.30	0.00	0.40	0.0012	0.0012	0.0024	0.0000	0.0032
Employment mix		0.42			0.0714	0.40	0.30	0.10	0.20	0.00	0.0285	0.0214	0.0071	0.0142	0.0000
Displacement		0.42													
Individuals			0.50		0.0357	0.00	0.10	0.25	0.25	0.40	0.0000	0.0035	0.0089	0.0089	0.0142
Activities			0.50		0.0357	0.00	0.20	0.10	0.35	0.35	0.0000	0.0071	0.0035	0.0124	0.0329
				Total	0.9977						0.1709	0.1926	0.2259	0.2410	0.1661

one variable reflected the same relative impacts for a particular characteristic, e.g., the variables "median family income" and "per capita income" both refer to "income generated." In such cases, one of these may be dropped. However, this judgment may be made only as one progresses through the assessment process; there are few instances where it may be predetermined.

51. Also presented in Table D7 are the RIC's and the final coefficient matrix for the SWB account. The RIC's were derived by using pairwise comparison and the professional judgment of the interdisciplinary team. An example follows.

Variable	Assignment of Values																					Sum	RIC
A	0	1	1	0	0	1																3.0	0.14
B	1						1	0.5	0.5	1	1											5.0	0.24
C		0					0					0.5	0	0.5	1							2.0	0.09
D			0					0.5				0.5				0.5	0	1				2.5	0.12
E				1					0.5				1			0.5			1	1		5.0	0.24
F					1					0				0.5			1		0		1	3.5	0.17
Dummy						0					0				0			0		0	0	0.0	0.00
Total																						21.0	1.00

Note: A = real income distribution.
B = life, health, and safety.
C = educational, cultural, and recreational opportunities.
D = emergency preparedness.
E = demographic characteristics.
F = community organization.

52. As shown in this example, it was the decision of the team that, in terms of the SWB of the residents of Anytown, the variables of "life, health, and safety" and "demographic characteristics" were equally the most important. This perspective may be contrasted with that of the RD account, in which the economic characteristics were given the highest priority. Although seemingly contradictory, this variation in weighting is explained by the variation in the emphasis of the two accounts involved. The RD account focuses on the development of the area, while the SWB account focuses on the quality of life, the more subjective aspects of living in Anytown.

53. The development of RIC's for the other variables follows the same process: judgment and weighting by the team. When RIC's and ACC's

have been developed for all of the variables, the impact display is presented in the final coefficient matrix. The final RIC and final coefficient matrix are obtained as discussed for the RD account. In this example, Alternative D, with a value of 0.2410 is the best alternative for SWB; while Alternative E, with a value of 0.1661, is the worst.

Comparison Between Accounts

54. The four accounts may be compared by using methods previously described in each of the accounts of alternatives. These methods may not be applied, however, until final scores from the final coefficient matrixes of all the accounts are scaled to a comparable range. The ACC's for the NED account are derived by scaling the net benefits for each alternative with the worst NED alternative always assuming a value of 0.0 and the ACC's summing to unity. The ACC's for the remaining accounts must conform to this procedure and range in order to be comparable.

55. To accomplish this transformation, the final scores from the final coefficient matrixes are used as a basis for the scaling procedure outlined in the NED account. The SWB account may be used as an example. Final ACC's within the SWB account are as follows:

A	B	C	D	E
0.1709	0.1926	0.2259	0.2410	0.1661

56. The most desirable alternative is assigned a value of 1.0; the least desirable receives a 0.0; and those remaining are assigned on the basis of their relative values within this range:

A	B	C	D	E
0.03	0.33	0.73	1.00	0.00

57. Finally, these point values are scaled to sum to 1.0:

A	B	C	D	E
0.01	0.15	0.35	0.49	0.00

58. This same process is followed for the ACC's of the RD and EQ accounts. The transformed ACC's for the accounts are shown below,

along with the RIC's determined for each account. These are multiplied together and the products shown in the final coefficient matrix of the analysis.

59. This display shows that Alternatives A, C, and D are fairly evenly ranked as far as being most desirable. Alternative E is the least desirable, with Alternative B in between. To examine trade-offs between accounts, it may be noted that Alternative A derives most of its strength from its high score in the NED account. The EQ account, on the other hand, provides its greatest weight in Alternative D. These kinds of comparisons are examples of the ways these numbers may be used to assist in project evaluation.

Account	RIC	ACC-Alternative				
		A	B	C	D	E
EQ	0.35	0.00	0.24	0.25	0.34	0.17
NED	0.35	0.53	0.00	0.25	0.14	0.08
RD	0.15	0.42	0.31	0.18	0.09	0.00
SWB	0.15	0.01	0.15	0.35	0.49	0.00

		Final Coefficient Matrix-Alternative				
		A	B	C	D	E
EQ	0.35	0.00	0.0840	0.0875	0.1190	0.0595
NED	0.35	0.1855	0.00	0.0875	0.0490	0.0280
RD	0.15	0.0630	0.0465	0.0270	0.0135	0.00
SWB	0.15	0.0015	0.0225	0.0525	0.0735	0.00
Total		0.2500	0.1530	0.2545	0.2550	0.0875

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